How Bulk Assembly Changes....

MILK MARKETING COSTS

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SUMMARY

Handling milk in bulk tanks, both for cooling at the farm and for hauling from farms to plants, is a new and rapidly growing technology in many milk markets. Milk assembly, farm to plant, includes the tasks of cooling, collecting, hauling and receiving the milk. The assembly of milk by bulk tank is potentially important to farmers, milk dealers, haulers, and other milk marketing agencies; it is certain to affect their relations with each other and their methods of doing business. Among the more important factors which contribute to the changes in milk marketing with the adoption of bulk assembly are (1) the overall reduction in farm-to-plant cost of cooling, hauling, and receiving the milk, (2) the uneven distribution among milk buyers, haulers and farmers of the changed tasks and costs accompanying the new equipment and methods, and (3) the increased mobility of the milk as collected from farms for hauling to market.

Milk in bulk moves more freely and over longer distances than milk in cans. It can be held longer without appreciable change in quality. It is less closely identified with the farm where produced or with a particular plant as a regular destination, day after day. The feasibility of reloading milk from truck to truck without recooling makes it possible to bypass country plants needed for assembly of milk in cans and to ship milk longer distances to market. The generally lower hauling cost under bulk assembly may result in enlarged milk-supply areas of individual plants, wider zones of overlap of the supply areas of adjoining plants, and a larger number of potential outlets for the milk from each farm.

With bulk assembly the customary tasks in cooling, hauling, handling, and receiving the milk are redistributed somewhat among the milk dealers, haulers, and farmers. The accompanying costs are changed also. Costs with bulk methods are generally higher on most farms and lower on milk collection routes and at plants converted completely; the amount of change varies with milk volume and equipment capacity. Changes may follow in the structure of milk prices and price premiums, in the level or structure of hauling charges, or in the amount of subsidies paid by plants to haulers to cover part of the cost of milk collection.

The ownership and control of milk collection routes often is changed with bulk assembly. The level and structure of hauling rates appear to be more closely related to real cost with bulk than with can hauling. Savings on the typical tank milk collection route result from larger load capacity, hauling more than one load daily, picking up larger loads of milk per farm, or picking up the milk every other day. These contribute to a larger volume of milk per day and per mile, and on most routes to lower truck cost per hundredweight of milk.

At most milk plants, bulk assembly offers opportunity for substantial savings, once the plant is completely converted. With bulk, more flexibility in receiving schedules is possible, but more storage may be needed. Investments in equipment for receiving and cooling the milk are lower for bulk than for can receiving. Cost of labor, utilities, and cleaning supplies are less for bulk than for can, with savings mainly in receiving-room operations. Total savings vary with plant size and with how efficiently labor was being used before the shift to bulk.

Farms with above-average daily milk production (and less pronounced seasonal variation in production) tend to be the first to install bulk milk tanks. Farms tend to increase their milk volume following conversion to bulk handling. For sufficiently large daily milk volumes, cooling milk in bulk may be less costly than by can, but on most farms fixed cost is higher for bulk than for can. Cost is lower for larger tank capacities, full utilization, and seasonally uniform production. Consequently, small-volume producers tend to

install the larger tank needed for skip-day collection, to increase their milk production, and to level it seasonally.

With bulk assembly, a part of the labor and costs of receiving milk is shifted from the city milk plant to the farm. Part of these tasks are done by the truckdrivers, part become the responsibility of farmers. The tank-truck driver usually is paid more than the driver on a can truck. The farmer's earnings for the added functions he assumes with bulk handling (and for his changed costs) are not so certain as the truckdriver's. An important question is whether or not the sum of net saving and reduction in hauling rate is adequate to amortize the farmer's large investment for equipment and high operating cost. The farmer usually is able to offset only a part of his increased costs with savings from reduced milk loss, and the smaller amount and less difficult chore work. In most cases, dealers have paid farmers a premium for bulk-handled milk to encourage them to install farm tanks. This has helped the plants to convert more fully and obtain larger cost savings.

The impact of bulk milk assembly on the structure of milk marketing and milk supply will depend in part on the rate and extent of shift, as well as relative costs. The shift from can to bulk equipment among milk plants, milk routes, and farms will likely continue. The shift appears likely to be rapid in some milksheds and markets, slow in others. Many plants now equipped for dual receiving may close their can receiving lines in the years ahead. Many can shippers may need to change their fluid milk market outlets. Some farmers may find in bulk assembly an obstacle to their continued milk production, others an opportunity to continue and to expand.

The impact of the shift to bulk milk handling on the cost of milk marketing will be affected in part by the rate and extent of the shift. Part of the estimated saving will result from continuing reorganization of functions to maintain and increase efficiency for both can and bulk milk handling as new equipment is installed. Part will result directly from new equipment. Overall savings in milk assembly costs for the United States are estimated at $5 to $12 million annually when the development of bulk assembly farm-to-plant reaches its peak and levels off.

HOW BULK ASSEMBLY CHANGES MILK MARKETING COSTS

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INTRODUCTION

The practice of handling milk in bulk for cooling on farms and for hauling farm to plant has grown rapidly since about 1953. By December, 1956 there were an estimated 57,000 bulk milk cooling tanks on farms, nearly double the 30,000 a year earlier; early in 1953 tanks on farms numbered only 6,000 (11, 12).[1] The assembly of milk, farm to plant, including the combined tasks of cooling, collecting, hauling and receiving the milk, is changed in many ways when bulk replaces can equipment and methods. The rapid spread of milk assembly farm to plant by bulk tank has been marked in many areas by such problems as availability of farm tanks and tank trucks, availability of funds to finance installations, changing market outlets, prospective changes in costs of cooling, receiving and hauling milk whether by tank or can, meeting sanitary requirements, and maintaining milk quality.

The shift to bulk assembly has been uneven and spotty, proceeding rapidly in some milksheds and markets and slowly in others. Both large and small plants have been converted to bulk or have been scheduled for converting; both cooperatives and proprietary corporations have installed bulk milk receiving systems. Both large and small volume milk producers have shifted to bulk, but larger sizes predominate. Many small farmers see in bulk assembly an obstacle to their continued milk production; others see in it an opportunity to continue and to expand.

About 600 milk plants were reported equipped to receive part or all of their milk by bulk in mid-1955. At many milk plants substantial saving in labor may be expected when the system is converted from can-receiving to bulk-receiving. One source of such savings is that most of the milk-receiving operations traditionally performed at milk plants under can assembly are transferred to the farm under bulk assembly. Similarly, the labor requirement and labor cost for milk receiving are shifted from the plant receiving-room crew to the tank-truck driver; and much of the investment in milk-receiving and milk-cooling equipment is shifted from the plant to the farm.

In many milk producing areas, farmers have viewed the possible entry of bulk milk assembly with mixed feelings. The prospect of added investment in equipment, and the increased and long-term fixed costs, have in some instances been viewed as prohibitive, with the small farmer faced with prospective loss of his market outlet for milk or higher can-hauling costs. In other cases, the large investment and increased cost have been viewed as worthwhile in order to eliminate the lifting and washing of heavy milk cans, often the necessary price of attracting or keeping farm labor needed to continue to handle an existing dairy herd, or to be able to expand it to a more profitable herd size.

Farmers, haulers, and milk-plant operators have felt the need for further information about bulk milk assembly--the amount of added investment required, the amount by which costs may be increased, and the possibility of cost-offsets through lower hauling charges or improved prices. Much of the information available was marked by widely conflicting claims with respect to which costs might increase, which costs decline, and the amount of the changes. Those desiring to shift to bulk were able to marshal considerable evidence of cost savings that would encourage the shift; those uncertain about the

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[1] Underscored figures in parentheses refer to Literature Cited, page 77.

change could find comfort in much data that seemed to discourage bulk handling as uneconomic (3).

This report presents a detailed analysis of changes in costs and practices that have occurred and that may reasonably be expected to occur with the growth of bulk assembly of milk farm-to-plant. It contains data and other information heretofore available only in widely scattered sources, but it represents more than a summary compilation of available data. The conflicting conclusions and wide ranging costs that have been reported were analyzed and evaluated in order to develop reasonably consistent conclusions to four main questions:

1. What effect will bulk assembly farm-to-plant, including farm bulk cooling and handling, bulk transportation by tank trucks, and bulk receiving at plants, have on the quality of fluid milk at the farm and on fluid milk products?

2. How will bulk assembly affect the cost of marketing milk, of cooling and handling milk at farms, collecting and hauling milk farm-to-plant, hauling between plants, and receiving and cooling milk at plants?

3. How much will the cost of assembling milk change as marketing facilities and practices are reorganized at the farm, on the route, or at the plant?

4. How are the net savings likely to be distributed among farmers, haulers and milk-plant operators?

One of the more important purposes of this publication is to stimulate and facilitate further research relating to these problems.

Answers to these questions are necessary to understanding the probable future rate of the shift to bulk assembly, the probable equilibrium point of balance of bulk and can assembly systems, and its impact on milk marketing structure and practices.

HOW BULK ASSEMBLY AFFECTS MILK QUALITY AND VOLUME

The various can and bulk methods of handling milk affect the market quality of the milk in different ways, and affect the quantity of milk lost in handling. The method of handling milk may affect its marketability, use, and price, by affecting the flavor, odor, bacteria content, and amount of foreign matter and sediment. Milk handled in the bulk may show different market quality than milk handled by can. In addition, the amount of milk lost in handling is usually less for bulk than for can assembly systems, and there may also be a reduction in butterfat loss.

With bulk assembly the quantity of milk sold is determined at the farm rather than at the plant and is determined by converting a measured volume of milk rather than by actual weight. The loss of milk, though smaller in amount than with can handling, is borne by the milk dealer instead of the farmer. For these reasons, the accuracy of measurement of the quantity of milk purchased has become a more troublesome question to milk buyers, producers, and State agencies responsible for administering regulations of weights and measures.

Milk Quality

Quality of milk as measured by bacteria count, by flavor and odor, or by freedom from sediment or foreign material, is affected by modern trends in producing, processing and distributing milk and milk products. As a result of changes in technology, scale of operation, milk volume per farm or frequency of milk collection, the time milk is held in the raw state is increased and the number of times raw milk is handled is increased. Today milk is produced in larger volume per farm, and in more specialized and concentrated milk-producing areas than ten years ago. It is hauled longer distances to market (159, 343) in larger-volume containers, with the load mixture representing

larger numbers of herds and farms. The growing use of farm tank cooling and bulk tank milk collection has encouraged less frequent delivery of the milk to plants.

Some undesirable physical and chemical changes in the milk that may occur during handling may be intensified by these changes in equipment and practices (1, 6, 16, 32, 68, 126, 179, 183, 208, 247, 261, 262, 270), and some new problems may be introduced by the more frequent agitation, pumping and mixing. For example, Atherton reports Wisconsin studies show "certain aspects of raw milk quality before and after conversion to bulk tank pick-up at the farm resulted in findings that do not agree with results of many published studies. Protein stability and creaming ability have been lowered in many instances since tank truck pick-up was adopted" (19). Nevertheless, improved milk quality after shifting from can to bulk farm cooling was reported by many plants and by over one-half of the 200 farmers having farm tanks in the Chicago, Ill. milkshed in a 1953 survey by the Wisconsin Agricultural Experiment Station (259).

Bacteria count

Bacteria count, a common index of milk quality, is measured by numbers of colonies per milliliter of milk. One of the main advantages of mechanical milk-cooling systems on farms is that milk is rapidly cooled to a temperature at which bacterial growth is minimized (1, 6, 16, 19, 59, 275). With outside temperature over 90 degrees, the temperature of milk on arrival at the plant ranged consistently 10 degrees lower for bulk milk than for milk in cans, according to tests at a large dairy plant in Los Angeles, Calif. reported by Ellison (115). Other reports showed varying amounts of difference in temperature of milk handled by bulk compared with can (72, 115, 338) as follows:

Location	Range in temperature of milk (degrees F.) received at plants when handled by---- Bulk	Can
Los Angeles, Calif.	39-46	49-58
Oakland, Calif. (average)	44	48
Haddonfield, N. J.	38-39	45-53

The more rapid cooling, and the lower temperature at which the milk is held at the farm and on the milk route, with bulk compared with milk in cans (170), lengthens materially the time milk can be stored at the farm without seriously affecting the bacteria count.

Bacteria counts are taken of samples of the raw milk as received from the farm and of the milk products as ready to leave the plant for distribution to consumers. These tests allow management and the health authorities to check on the cleanliness with which the milk was produced, handled and processed.

Widely scattered reports show a consistently lower range of bacteria count for milk handled farm-to-plant by bulk (11,000 to 37,000) than for milk handled by can (40,000 to 100,000), (tables 1, 2, and 3). The counts for both bulk and can samples range well below 200,000, the maximum limit most commonly prescribed by sanitary authorities for milk delivered from producers (86, 87, 159, 208, 318, 324, 325). Individual observations for milk handled by either can or bulk vary widely among farms and by season. The bacteria counts averaged lower for bulk than for can samples over each season, winter, spring and summer, in tests at the Oklahoma Agricultural Experiment Station (175) and the range of reported bacteria counts averaged lowest for winter and spring and highest for summer in tests at both the Oklahoma and Connecticut Agricultural Experiment Stations (175, 283) (table 2). The range of reported bacteria counts is generally similar for bulk milk collected daily (3,000-37,000) and for bulk milk collected every other day (3,100-33,000). The range of reported bacteria counts for milk handled by bulk is generally similar for studies by State agricultural experiment stations (3,000-31,000) and for tests and observations made by commercial dairies under a typical range of operating conditions (11,000-37,000) (tables 1 and 3).

TABLE 1.--BACTERIA COUNT OF RAW MILK COOLED AND HANDLED FARM-TO-PLANT BY BULK AND BY CAN

Region	Number of observations	Bacteria count[1] for milk handled by:		
		Can	Bulk	
			Collected every day	Collected every other day
		Average		
West	20	68,568	32,273	---
Southwest	51	54,700	17,400	---
Midwest	([2])	---	4,700	5,250
Northeast	142	---	6,900	7,800
		Range		
Southwest[3]	3-7	18,800-112,000	10,900-31,100	---
Midwest	([2])	---	[4] (600-2,400 [5] (3,000-6,400	[5] 4,000-6,500
Northeast	7-14	---	3,000-22,000	3,100-28,000

[1] Standard plate count.
[2] Not available.
[3] Range in monthly averages.
[4] Range for individual observations at various sampling positions within tank and valve.
[5] Range for individual observations of various tanks.

Compiled and calculated from data published by the California, Oklahoma, Wisconsin, and Connecticut agricultural experiment stations.

Smith, Dowd, and Anderson reported (283) that average bacteria counts were lowest in March and highest in June in a year's study in Connecticut. They report: "The few high plate counts were usually traceable to human errors such as failure to turn on the tank agitator and failure to properly clean the milking equipment." The importance of human failure (e.g., lax procedure in cleaning dairy barn and milk house equipment) as a factor influencing high bacteria count in milk handled by bulk in Indiana has also been illustrated in observations by Moseley (227, 228).

Bulk handling farm-to-plant is no substitute for dairy farmers' daily sanitation practices. Atherton, Bradfield & Gotthelf found that bacteria counts were higher in milk from one-third of the Vermont farms studied after conversion from can to bulk. Prouty reported psycrophylic bacteria growth in tank-cooled milk (20, 256). The bacterial content of the raw milk, the care taken, and methods used in handling the milk, are important factors affecting the bacterial content of the finished products. In tests at the Michigan and Oklahoma Agricultural Experiment Stations, bacterial counts were only about half as large in the cream and in each of 4 types of fluid milk products made from raw milk that had been cooled and hauled by bulk, as in corresponding products made from milk handled by can (175, 195). In the Michigan study the tests with bulk-handled milk were made a year after those with milk handled by can. Standard plate counts of products made from milk handled in bulk ranged from about 11,000 to 24,000 among the various products, compared with 30,000 to 142,000 for products made from milk handled in can (table 4).

TABLE 2.--SEASONAL VARIATION IN BACTERIA COUNT OF RAW MILK COOLED AND HANDLED FARM-TO-PLANT BY BULK TANK AND BY CAN

Area	Season	Range in monthly average bacteria count for milk picked up:[1] Daily	Every other day[2]	No. of observations
Milk cooled and handled by bulk tank				
Northeast				
	1953-4 winter	7,400	7,000-8,500	24
	1954 spring	3,000- 5,400	3,100-6,900	39
	1954 summer	11,000-22,000	17,000-28,000	37
	1954 autumn	4,900- 6,300	5,000-6,900	32
Southwest				
	1953-4 winter	11,000-13,300	---	16
	1954 spring	10,900-31,100	---	17
	1954 summer	12,100-31,100	---	13
Milk cooled and handled by can				
Southwest				
	1953-4 winter	22,400-53,800	---	16
	1954 spring	81,700-112,000	---	17
	1954 summer	18,800-55,000	---	13

[1] Standard plate count. [2] Refrigerated 500-gal. portable tank equipped as truck-trailer.
Compiled from data published by the Oklahoma and Connecticut agricultural experiment stations.

TABLE 3.--INDUSTRY REPORTS OF BACTERIA COUNTS IN RAW MILK COOLED AND HANDLED FARM-TO-PLANT BY BULK TANK IN COMMERCIAL OPERATIONS

Area	Year	Season	Bacteria count	Number of: Observations	Farms
Milk picked up every day					
Northeast					
New Jersey...............	(1952	Summer	33,000	64	16
	(1951	Spring, summer	37,000	128	--
Maryland.................	1952	Summer	14,000	69	7
Washington, D. C.........	1952	Spring, summer	14,000	147	--
Midwest: Iowa............	1952	Summer	20,000	42	6
South: South Carolina......	(1952 (1951	August	23,000	48	--
Milk picked up every other day					
Midwest					
Iowa.....................	1952	Summer	33,000	60	6
Indiana..................	1952	Summer	13,000	25	3
Ohio.....................	1952	Summer	27,000	24	6
South: South Carolina......	(1952 (1951	August	11,000	45	6

Compiled from industry sources.

TABLE 4.--BACTERIA COUNTS FOR CREAM AND SELECTED FLUID MILK PRODUCTS FROM MILK COOLED AND HANDLED FARM-TO-PLANT BY BULK AND BY CAN

Area	Product	Bacteria count for milk handled by[1]	
		Bulk	Can
Southwest[2]	Pasteurized...............	107	143
Midwest[3]	Pasteurized...............	19,571	40,226
	Vitamin D.................	20,666	29,540
	Standard homogenized......	24,222	49,836
	Chocolate.................	17,888	141,822
	Coffee Cream..............	10,881	32,346

[1] Standard plate count.
[2] Observations cover Jan.-May 1953.
[3] Observations cover Sept. 1953-March 1954 for can, Sept. 1954-March 1955 for bulk.

Compiled from data published by the Oklahoma and Michigan agricultural experiment stations.

Flavor and odor

Replacing a can cooler with a farm bulk milk tank may help to improve milk flavor as part of a general program of better sanitation, more rapid cooling, and more careful management. But it obviously cannot be expected to eliminate problems of flavor or odor that may be caused by poor practices or conditions of feeding, sanitation, herd management, or the health of individual cows. In fact, the change in equipment for cooling and handling the milk may intensify some problems and create others (105, 237, 238, 257).

Some feeds (silage or certain clovers, for example) may cause undesirable flavors in the milk if fed within 2 hours of milking. Some types of weeds or fruit (wild onion, garlic, or the Osage Orange for example) may cause lingering undesirable flavors in the milk for several days after being eaten. A musty barny flavor in the milk may indicate overcrowded and inadequately ventilated barns.

Undesirable flavors and odors need not be a problem, because they can mostly be controlled readily by management practices (278, 297). Where they become a problem, however, the entire tankful of mixed milk is affected even if the tainted milk represents only one cow's production. And since the tank-truck driver may reject an entire tank of milk because of undesirable flavor or odor, the risk of loss from this cause is higher with bulk than with can milk-handling systems.

Actually, losses from undesirable flavors and odors have been reported as small, both in number and in proportion of producers, in surveys in the Chicago, Ill. and Washington, D. C. milksheds, and in the Northeast and Pacific Northwest. (31, 257, 259, 270). Experiments at the Oklahoma Agricultural Experiment Station reported by Johnson, Olson, and Von Gunten (175) showed no difference in the flavor of pasteurized milk processed from raw milk that had been handled and cooled by bulk tank and by can.

These results indicate that a range of conditions may give rise to problems, but that the flavor problems have not been wholly solved.

The Vermont Agricultural Experiment Station tested the milk from 18 New England producers for 2 seasons, the milk being cooled and handled by can the first year and by

tank, the second. Feed flavors predominated whether the milk was handled by can or bulk, and "flat" and "weedy" flavors were more frequent in the milk handled by bulk (20). Bulk milk had the better flavor on the whole. The bulk samples scored lower in flavor than the can samples for about one-third of the producers. The bulk samples also had higher bacteria counts than the can samples for about one-third of the producers. Unclean, high-acid and rancid flavors were less frequent in the milk handled by bulk tank. The evidence is inconclusive; the data may have been affected to an unknown degree by differences in temperature, humidity or feed-quality factors between the two seasons (can samples having been taken and tests made in 1952, bulk samples and tests in 1954).

Rancidity

Rancidity is a special case of the flavor and odor problem and is reported to be widely considered as one of the major flavor defects of the milk supply (142, 272). Herrington (157) defined rancidity as limited to hydrolysis with liberation of fatty acids, and excluding oxidation. Following an extensive review of the literature on lipolysis and rancidity, he stated (157): "Several times in the history of the dairy industry new methods of handling or processing milk have activated the lipase system and produced rancid flavors." He cited first homogenization, then the change in temperature of cream separation as examples and, as the most recent, increase in the reports of rancidity that seem associated with the introduction of pipeline milkers and farm tanks. Dunkley and Kelly (108, 109, 110) reported in 1954 an increasing evidence of rancid flavor in milk in California in recent years, "with at least part of this increase appearing attributable to more extensive use of pipeline milkers and farm tanks."

Thomas, Neilsen, and Olson (307) reported excessive lipolysis occurring most frequently in milk from the pipeline milking unit in combination with the bulk tank. Herrington (157) reported acid numbers ranging as high as 2.6 and 2.9 for milk handled by pipeline milker and farm tank in New York State, well above the 0.5 acid number average for all samples taken at pasteurizing plants. These samples were taken from milk collected from farms daily. Gould and Harper (142) reported on tests made of milk from Ohio farms with the milk collected every other day. About one-third of the samples showed acid numbers of 1.4 to 3.2, well above the range of 0.4 to 0.8 indicating normal flavor stability. All of the samples with high-acid numbers came from farms with pipeline milkers. Samples taken on farms not using pipeline milkers were normal (219). This is similar to the experience of a Cedar Rapids, Iowa, dairy reported by Davis (98); the only rancidity problem among more than 400 farms with bulk tanks developed from a farm with a very long pipeline system.

Not all pipeline milking systems caused rancidity to develop. Herrington (157) reported that the rancidity trouble was traced in a number of cases to the existence of "risers" in the pipelines, vertical sections connecting one section of pipe with another at a higher level. The milk, forced upward through the risers in pumping, apparently suffered some damage to its physical structure, which in turn induced the increased enzyme activity causing rancidity.

Other factors discussed as possible causes for the development of rancidity include the effect of agitator design and speed (157, 224) or exposure to air from air leaks or air agitation (213, 295). Some attribute the onset of rancidity to temperature activation (66), particularly where the fresh warm milk from the second milking is added to the cool milk in the farm tank; others dispute this as a cause. March reports that tests in 1955 at the New York Agricultural Experiment Station (204, 205) showed that fresh warm milk from subsequent milkings added to the cool milk already in the farm tank caused no discernible lipase activity after 36 hours, and no flavors that could be detected by organoleptic tests even after being held 8 days. Nor could March find any significant amounts of lipase activity resulting from agitation (or lack of it) of the milk during cooling, or associated with breed of cow from which the milk was obtained.

Milk Volume Lost in Handling or From Stickage

Milk and butterfat may be lost from cans in any of three ways. On the farm, milk may be spilled when poured from the milking pail into cans, or between cans. On the truck, if cans are too full or roads too rough, or if the can lids do not fit tight, some milk may be spilled and it is likely to be largely cream. At the plant, milk may be spilled when the cans are dumped at the weigh vat, or lost as residue left in the can. The percentage loss of butterfat may be larger than the loss of milk. Cream rising in the can tends to form a cream "plug" and to stick to the can collar and on the face of the lid. For example, Rapp and Calbert (263) reported that milk remaining in the can averaged 5.4 to 5.6 percent butterfat compared with 3.5 percent to 3.6 percent butterfat test for the composite sample of all milk delivered to the plant.

Butterfat loss

The effect of bulk handling and transportation on the amount of butterfat lost in handling has been the subject of widely conflicting reports. At one extreme, Herrmann & Whatley (162) found 2.4 percent butterfat loss, twice as large as the 1.2 percent milk loss, in a study of the tank-truck shipment of milk from Wisconsin to Memphis, Tenn. About half of the butterfat was lost with milk loss and half from differences between butterfat tests at shipping points and destination plants. Differences in tests of buyers and sellers are not involved in farm-to-plant operations. But flaking out of butterfat from surge of the milk in the tank is involved. Preston (252) reported that about 0.11 percent of the total butterfat remained as container loss in the farm tank compared with 0.43 percent butterfat lost in cans. Pascoe (246) reported similar fat loss in milk tanks.

Baker, McDaniel and Bondurant (24) reported tests at the Delaware Agricultural Experiment Station which showed no significant difference in butterfat content at the farm and at the plant when the milk was transported by 10-gallon can. This contrasts with reported trade experience (140, 216, 241, 330) of fat test differences ranging from 0.5 to 1.0 points,[2] where the milk was pumped off from farm tanks into cans and the tests were made from samples taken both at the farm tank and at the plant weigh tank.

Herrmann (158) reported variation with procedure, method of handling, and among individual loads handled by the same method, in a study of long-distance tank-truck movement of milk from Wisconsin to Memphis. "Butterfat test for undivided loads averaged 0.04 percent decline, for divided loads 0.0405 percent. Loss of milk was an influential factor in loss of fat in divided loads but was relatively unimportant in undivided loads," he reported.

Freezing of the milk or partial churning when the agitator in the farm tank was operating with too small a milk volume in the tank were among the factors causing butterfat loss from fat separation, as found in New York tests reported by March (202).

Bradfield & Gotthelf (42) reported "there seems to be no evidence that a producer's test will change when he shifts from can to bulk handling if he was getting correct tests with cans." Their study of weigh-can sampling at the Vermont Agricultural Experiment Station showed about half of plant samples were in error and about two-thirds of the errors favored the farmer. They reported that an average difference in test amounting to 0.019 percent was found for 24 lots of milk split and handled half by bulk and half by can.

The variation in amount of butterfat loss--or of differences in the amount of butterfat test with can and with bulk systems--may be due in part to differences in procedure, differences among samples or in universes sampled, or recall error, as well as to actual loss or change. Comparisons that are based on herd averages at different time periods need particular care in their interpretation.

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[2] A point is one-tenth of 1 percent.

An example that illustrates both the possibility of recall error and of different samples and universes is reported by Beal and Twining (31). From identical groups of 42 dairy farmers in Maryland and Virginia, the average butterfat test of the milk as sampled routinely at the plant was slightly less after farm tanks were installed, 3.69 percent for the last 6 months handled by can compared with 3.65 percent for the first 6 months handled by bulk tank. With the observations for individual producers grouped by the type of change, an increase in average butterfat test occurred for 6 out of 10 producers studied. However, 2 out of 3 producers surveyed during the first year after installing tanks reported that their butterfat test did not change following conversion to bulk handling. The distribution of cases was as follows:

Direction of change in butterfat test after installing farm tank	Number of producers reporting change	Number of producers with calculated change
Increase	17	25
No change	37	3
Decrease	5	14
Total	59	42

None of the producers who reported a change in butterfat test attributed the difference entirely to the use of tanks.

Variation among samples is illustrated in data reported by Sinclair (282). In limited tests at the Vermont Agricultural Experiment Station, the butterfat test of milk dripped from the cans after dumping by conventional receiving room procedure was found to average 4 to 5 points below the plant test in half of the observations, 3 to 9 points above the plant test (based on a sample taken before the can was dumped) in the other observations.

Differences in fat test variation by breed have been reported by Bradfield and Gotthelf (42), in recent tests; and by size of herd, breed, stage of lactation, and day for individual cows, in Washington Agricultural Experiment Station studies by Erb, Goodwin, McCaw, Morrison, and Shaw (116), and Oklahoma Agricultural Experiment Station studies by Blakely and Brewer (36).

In general, butterfat tests of the milk should be more nearly accurate for milk handled by tanks as compared with can. When milk is hauled over rough roads, some butterfat may be precipitated as cream flakes from agitation. This is a more likely problem on can-haul routes as motor-truck weight limitations may in effect restrict bulk tank trucks from using certain roads or highways (189). When the milk sample is drawn at the plant, any cream that has risen to the surface must be mixed uniformly through the milk in order that the sample be truly representative. When cans of milk are dumped into the plant weigh vat, blending of the cream in the milk may be incomplete without prolonged stirring, and cream streaks may be visible even when the milk is poured into a tank equipped with baffles designed to improve mixing. On the other hand, milk handled in bulk, farm-to-plant, is mixed by a motor-driven agitator before the sample is drawn. The efficiency with which the cream and milk are blended is affected by the size and design of the agitator blade and by its speed. However, 2 minutes' agitation time has been reported adequate for practical operating conditions for mixing of the milk and cream after the milk had stood quiet for as long as 12 hours, in field studies in Minnesota, Wisconsin, New York, and Vermont reported by Preston (252), Liska and Calbert (193), Marth, Hunter and Frazier (204), March (202), and Bradfield and Gotthelf (42).

After extensive field tests under commercial operating procedures in Minnesota, Preston observed (252): "Customary practices employed by the bulk-tank truck drivers permitted variation in agitation time from 2 minutes to 6 minutes per tank. Variations in agitation time within this range did not affect adequacy of blending." In the Wisconsin and Vermont tests, one minute was found adequate (42, 193, 204).

Milk loss

The amount of milk lost in handling by can has been reported to range from extremes as low as 0.2 percent in Wisconsin tests by Rapp and Calbert (263), to as high as 3.1 percent in Vermont tests by Sinclair (282), (table 5). Average losses found in large-scale tests of commercial operations have been reported by Preston (252) at 0.4 percent for a large Minnesota dairy and by Herrmann and Whatley (162) as 1.4 percent in Tennessee. Losses within these ranges were reported for Delaware experiments by Baker, McDaniel, and Bondurant (24), for Oklahoma tests by Johnson, Olson, and Von Gunten (175), and for commercial dairy experience in Iowa by Swaner (300), and in New York by Fisher (124).

The variation in amount of milk lost can be explained as due partly to differences in procedure and partly to variation in draining time per can at the dump vat. Thus Sinclair

TABLE 5.--WEIGHT AND BUTTERFAT LOSS FROM CONTAINER STICKAGE FOR MILK COOLED AND HANDLED FARM-TO-PLANT BY BULK AND BY CAN

Location	Amount of loss for milk handled by--	
	Bulk	Can
Milk		
	Percent	*Percent*
Northeast		
Vermont	---	[1] 0.6
Vermont	---	[2] 0.8-3.1
Delaware	---	0.5
Midwest		
Minnesota	[3] 0.087	0.4
Minnesota	---	[4] 0.65-1.7
Wisconsin	---	[5] 0.2-0.75
South		
Oklahoma	---	[4] 0.287-0.366
Tennessee	[6] 1.2	[7] 1.4
Butterfat		
Midwest		
Minnesota	---	[8] 0.05-0.1
Minnesota	0.11	---
South		
Tennessee	[9] 0.05	[7] [9] 0.04
Tennessee	[6] 2.4	---

[1] Drippings from 78 lots (217 cwts.) of milk.
[2] Draining time 12 to 20 seconds.
[3] Milk solids lost in farm tank only.
[4] Pounds per can.
[5] Dumping rates 5 to 10 cans per minute.
[6] Loss in long distance tank-truck movement.
[7] Loss in split-load distribution of tank-truck loads among small dealers by can.
[8] Large-volume commercial operation.
[9] First differences in butterfat test.

Compiled from published reports of research by Vermont, Delaware, Minnesota, Wisconsin, Oklahoma, and Tennessee Agriculture Experiment Stations, U.S. Bureau of Agricultural Economics, and U.S. Farm Credit Administration.

(282) reported a range from 0.6 percent to 1.8 percent with method in the average loss between farm and plant in Vermont, and from 0.8 percent to 3.1 percent with length of draining time per can at the plant. The latter result is closely similar to the range in amount of loss found in a test under large-scale commercial operations in Minnesota reported by Owens (241). Schwarzkopf (274) reported that milk lost when cans are dumped could be reduced to a minimum at 21.5 seconds draining time per can. He suggested that draining time could be increased without reducing the number of cans dumped per minute by modifying the design of the dump vat and position of the conveyor.

Herrmann (158) discussed causes of milk and butterfat shrinkage occurring in transporting and handling milk between Wisconsin shipping points and receiving plants in Memphis, Tenn.: "The shrinkage varied with the method of finding the weights and with the method of handling. There were also large variations among loads handled by the same method. For shipments delivered as full loads to a single buyer, most of the discrepancies in weight may be explained by inaccuracies in measuring the volume and by differences between the figure used for weight per gallon and the true specific gravity of the milk at its actual temperature and fat content." Weight changes on 48 shipments delivered as full loads to a single buyer averaged 0.36 percent loss; on 88 loads repackaged from tanks into 10-gallon cans (for less-than-tankload distribution to smaller handlers) 1.4 percent, or about 4 times as large. The loss of milk in the process of repacking tank lots into cans resulted partly from discrepancies in measurement, but it was in large part an actual physical loss.

Preston (252) reported losses of milk handled by bulk about 75 percent lower than with can, in 60-day tests at a large-volume Minnesota milk plant. About 0.09 percent of the total solids remained in the farm tank; with cans, 0.4 percent of total solids were lost.

Although the problem of milk and butterfat loss in handling is widespread, it has received only limited attention in recent years. Beal and Twining (31), found that 9 out of 10 commercial dairy farmers in Maryland and Virginia reported losing some milk spilled from cans at the farm. Seven out of 10 farmers reported losing some in transit or at the milk plant.

With tanks, there is less opportunity for milk to stick to the container than with cans. A 2,500-gallon milk tank, for example, has about 360 square feet of surface to contact the milk, and a 2,500-gallon truck tank about 400 square feet, compared with about 1,500 square feet of contact surface in 250 10-gallon cans. At larger volumes, the relatively smaller contact surface with tanks is even more pronounced. Sonley (286) reports: "The wetted surface of a tank is only about one-seventh that of cans required for the same size load. A 10-gallon can has 111 square inches surface per gallon capacity; a 1,200-gallon tank, 29 square inches per gallon; and a 3,000-gallon tank, only 15 square inches per gallon." The amount of milk solids lost in bulk-handled milk was larger than expected from a comparison of areas of wetted surface of cans and tanks, in the Minnesota tests (252).

Factors Affecting Measurement of Quantity Sold

Where milk is cooled and handled by can, quantity sold is determined for each producer as the milk arrives at the plant. The milk from all the cans of a single producer is dumped into the weigh vat and the weight is determined and recorded for his entire shipment. Where the milk is cooled and handled by bulk tank, the quantity sold by each producer must be determined when the milk is picked up. With bulk handling the total quantity of milk in the farm tank is credited to the producer even though there is some stickage loss when the milk is pumped to the truck tank. The quantity of milk in a bulk tank is determined by measuring the volume and converting the volume to a weight equivalent, at the rate of 8.6 pounds per gallon. The conversion factor is based on an average specific gravity of milk.

In the early days of the dairy industry, practically all milk was bought and sold by measure, i.e., by the can or the gallon. Buying by measure was reported by Babcock in 1947 (23) to have been largely abandoned in favor of more practicable systems that are also more nearly equitable to producers and distributors. Weighing, as compared with measuring, the milk when it arrives at the plant provides a more accurate means of determining the actual quantity. Babcock reported one experiment in which a discrepancy of 1.88 percent was found for 346 shipments of milk totalling over 6,000 gallons (equivalent to 3 or 4 tanker loads) between quantity as determined by actual weight and by converting volume to weight.

Although quantity can most reliably be determined by actually weighing the milk on an accurate scale that is functioning properly, some practical difficulties are involved in the use of scale-mounted farm or truck tanks. With a separate weigh vat mounted on the truck, there is a sacrifice of truck space that could be used for hauling capacity, and of the time required for filling and emptying the weigh vat. Either a separate weigh vat or a scale-mounted truck tank might need frequent checking and readjusting to correct out-of-balance problems that may develop from vibration as the tank truck travels along country roads and lanes. With a scale-mounted farm tank, water clinging to the tank surface and scale from frequent washing could affect scale balance or could cause error in weight determination, although with sufficiently large tanks and milk volume per farm the size of error becomes relatively unimportant (13, 233).

In the dipstick method of measuring the volume of milk for which the producer is credited, the tank-truck driver measures the depth of the milk or its distance from a reference point on the tank lid, with a rod or sight tube graduated in intervals of 1/16 or 1/32 inch. The driver converts this linear measure to volume by referring to a chart kept in the milk house and prepared especially for that particular tank. In a few States the chart is prepared under supervision of the weights and measures regulatory agency; in others its accuracy is checked after being prepared by the tank manufacturer or supplier. The charts vary as to construction. In some States they show only gallons equivalent to depth and in others, both gallons and pounds, based on the weight of 8.6 lbs. per gallon. This method of determining the quantity sold is widely used despite the possibility of errors of measurement that could be substantial.

Three main sources of error in measuring bulk-handled milk with a dipstick have been reported in investigations in the Pacific Northwest and Northeast. They include: (1) Dipstick readings that did not reflect accurately true volume, from differences between dipsticks of various finishes or from foam, upward creep of the milk surface along a cold or greasy dipstick, or distortion of the shape or level of the tank (2, 18, 67, 153, 169, 185, 214, 279, 280); (2) human error (or differences between observers) in reading, converting or recording the measurement (143, 172, 173, 279, 298); and (3) variation for a particular lot of milk from the average specific gravity (202).

A possible alternative method of determining the quantity of milk sold is by measuring it through a flow meter similar to that used in tankload deliveries of gasoline or fuel oil. This would eliminate the possibility of error from bulging or settling of the tank, and it would reduce the possibility of human error, especially if the meter reading is registered by a printer-recorder. But metering devices encounter the problem of eliminating air which is mixed in the milk that is being measured. The problem of variability in specific gravity would still remain, even if a way could be found to eliminate the air. Perry summarized the technical problems of developing a suitable meter for use with milk thus: "As yet there is not an accurate meter which is readily disassembled for cleaning, nor a sanitary meter of the desired accuracy" (249).

Partly because the errors of dipstick measurement can by careful management be kept low, there is a widely held opinion that measuring the volume of milk and converting it to weight-equivalent is likely to continue as the method of determining the quantity sold by the farmer under bulk assembly, at least until the scales or strain gages being developed can be both inexpensive and accurate under varied and adverse usage conditions. This situation complicates the work of State agencies charged with the policing of weights

and measures regulations.[3] The regulatory agencies argue that they are not able to officially approve the conversion-chart "weight" equivalents determined by measurement of volume since volumetric values can be converted to weight values only upon the basis of some assumed equivalent.[4] Since the legality of official certification of weight values on the chart of a farm milk tank has not been determined and may be subject to question, the National Bureau of Standards and the National Conference on Weights and Measures recommend that State regulatory agencies limit their approval of farm milk tank charts to gallonage values only as required by the 1955 Code (174, 315). The equivalent weights corresponding to the respective volumes would be listed on an auxiliary chart without official approval by the weights and measures official, and would represent conversion values mutually agreed upon by the milk buyer and the farmer in "private" rather than "public" sale. An alternative that would relieve the regulatory problem is the proposal to return to the sale of milk by volume (173).

Some of the apparent shrinkage of tank milk may well be container stickage or loss rather than inaccurate measurement. Suckling reports finding that side-discharge tanks were often not completely emptied with the centrifugal pump apparently because of slow draining; the haulers were anxious to avoid the delay encountered in completely pumping the milk from the tank bottom (298).

The extent of the problem of apparent milk loss due to errors of measurement is subject to conflicting reports (111, 166). In the Northwest, it has been reported that upwards of 8 farm tanks and dipsticks out of 10 were found accurate on recheck (185, 333). From some milk plants, however, have come reports of "paper" losses of large amount, the loss experience from measurement problems varying among firms.

Suckling summarized the experience of a large western milk company with the measurement problem at their Seattle, Wash., plant as follows: "Product shrinkage on individual trucks is occasionally greater than we can account for and checking loads by public scales is not sufficiently accurate. We are installing liquid level gages on two of our holding vats in the plant to check on weights" (298).

The extreme range in amount of loss is indicated by two reports from the West and Midwest (58, 211). A Western firm is reported to have experienced a $30,000 annual plant loss due to errors of measurement. To solve the problem 3 storage tanks of 3,500-gallon capacity were installed and equipped with a liquid-level gage controlled by a photoelectric mechanism to record the weight of the tank contents. An Oakland, Calif. dairy firm reported no problem with accuracy of measure (26). In the Midwest, in summarizing the first year's experience of a Dayton, Ohio, plant receiving milk from 7 farmers with tanks, Bumstead reported "checks of volume picked up as measured by the dipstick, platform scales and receiving room scales showed calibration to be reliable for volume determination" (58).

In summary, milk handled by bulk is usually of better quality (lower temperature and usually lower bacteria count) than milk handled by can, although the minimum amount of milk subject to risk of loss from undesirable flavor or odor is increased at least tenfold, when a farmer replaces milk cans with even a small tank. Milk lost by spillage or container stickage is reduced somewhat with the shift from can to bulk assembly, and the

[3] The regulation of weights and measures by the State or local governing authority is of long standing. Regulation over the weights and measures used in marketing milk includes the regulation of standard container sizes for each unit of sale over the range commonly used in trade, such as fractional or whole pints, quarts, and gallon; it includes also the regulation of the accuracy of scales or meters used in establishing the volume of sale for transactions that may involve large volumes, such as a tankload of milk, or partially filled containers, such as milk delivered to plants by can. It includes also the procedure and equipment used in sampling and testing the milk, for its sale value is determined not only by volume sold but also by butterfat content.

[4] The size of the error resulting from variation in specific gravity is indicated by March for varying temperature and butterfat content (202). He reported 0.6-pound error per 100 gallons of milk between milk at temperature of 40° F. (s.g. 1.032, weight 8.607 pounds per gallon) and 50° F. (weight 8.601 pounds per gallon); and 1.7 pounds error per 100 gallons for milk containing 5.6 percent butterfat (862.4 pounds), as compared with the conversion-chart equivalent (860.7 pounds). "Errors as a result of changes in the weight of a volume of milk due to temperature variations or compositional variations are relatively small, but they are systematic errors that do not cancel out with repeated readings over a period of time," March states.

loss is shifted from the farmer to the milk buyer. Offsetting the small losses of milk and butterfat, however, are many advantages and cost savings at milk plants.

HOW BULK ASSEMBLY AFFECTS MILK PLANT OPERATIONS

Bulk receiving of milk offers attractive opportunities for plant savings in investments and costs and for increased flexibility in operating practices. At a milk plant equipped to receive milk in bulk, the can-receiving operation can be eliminated, with considerable saving in equipment investment and labor, and the milk-cooling and can-washing operations can be reduced. The cost effects differ with the type and size of plant and the degree of conversion to bulk, ranging from large savings for a plant equipped so as to receive only bulk milk, compared with possible substantial increase in receiving cost for a plant equipped to receive by both can and bulk methods.

Changes in Equipment Investments

For converting existing milk plants from can to bulk receiving, the equipment that could be eliminated amounts to about one-third to two-fifths of the total investment in milk-receiving equipment (3, 4). This represents savings of about $6,000 to $8,000 for small or medium plant capacities, about $10,000 for large capacities and about $15,000 for very large plant capacities. The equipment eliminated includes can dumping equipment, weigh can and scale, can washer, can conveyors, platform and reject slide (table 6).

For these comparisons "small" capacities include plants with daily processing capacity in the range of about 200 to 400 hundredweight daily, "medium" capacities about 400 to 600 hundredweight daily, "large" capacities about 600 to 1,000 hundredweight daily and "very large" capacities, about 1,100 to 1,600 hundredweight daily.

The amount saved in equipment investment in the receiving-room averages somewhat less for building new bulk plants than for converting existing milk plants from can to bulk receiving rooms (26, 27, 75, 320). In constructing new plants; part of the savings obtainable from eliminating the receiving-room are offset by the increased milk-storage capacity that must be provided in order to obtain full advantage of the increased flexibility of bulk receiving (table 6).

Thus the saving in investment for a new bulk system compared with a new can system amounts to only about two-thirds as much for building completely new milk plants, as from converting a plant from a can-receiving operation to a bulk-receiving operation, unless of course the storage capacity is also increased for the converted plant. Any loss in discarding remaining use value in the can equipment being replaced also partially offsets some of the investment advantage obtainable in converting existing milk plants to bulk receiving.

The capacity of a milk plant ordinarily is increased as a result of converting from can receiving to bulk receiving. Initially, a milk plant can be converted to dual or all-bulk receiving merely by installing a pump inlet and small surge tank.

Often converting to bulk is a solution to a problem of finding more plant space without building an addition. The receiving-room space occupied by the can dump, conveyors, racks, and can washer becomes available for expansion of plant processing or storage capacity (115, 218).

The savings in investment calculated in these studies for the range from 100 to 1,600 hundredweight daily milk plant capacity are somewhat less than the $40,000 to $60,000 reported in converting individual Eastern and Pacific Coast milk plants from can to bulk receiving (115, 215).

In both latter instances, however, unique local factors were involved that contributed to unusually large savings.

TABLE 6.--INVESTMENTS IN MILK PLANT EQUIPMENT FOR RECEIVING MILK BY CAN AND BY BULK[1]

Model plants[2]

Item	Amount of investment in milk receiving equipment for intake capacities of:						
	200 to 400 cwt.			600 to 860 cwt.		1,100 to 1,540 cwt.	
	Can		Bulk	Can	Bulk	Can	Bulk
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Equipment that could be eliminated with bulk handling[3]....	5,665	[4] 8,395	---	9,955	---	14,610	---
Equipment that would be needed with either can or bulk handling....................	8,748	[4] 11,561	14,396	19,350	28,067	26,025	38,243
Storage vat[5]..................	(3,710)	---	(7,920)	(10,780)	(15,220)	(13,080)	(23,806)
Other[6]........................	(5,038)	---	(6,476)	(8,570)	(12,847)	(12,945)	(14,443)
Total.....................	14,492	[4] 19,956	14,396	29,417	28,067	40,635	38,243
Existing plants[7]							
Total.....................	20,400		---	22,400-23,800	---	45,800	[8] 41,700

[1] Plant capacities in daily milk volume: Small and medium, 200-400 cwt.; large, 600-860 cwt.; very large, 1,100-1,540 cwt. [2] Investments for plants as developed for Pacific Northwest, except as noted. [3] Equipment that would be eliminated with bulk handling includes conveyors (and for large plants, platform and reject slide), dumping equipment, weigh can and scales ... and can washer. The investment in receiving equipment that would be eliminated with bulk handling ranged 39% to 42% of total investment for small plants. [4] This plant developed for small to medium-sized cities in the Northeast. [5] In each plant size range, the higher investment in storage vats for bulk compared with can represents larger storage capacity for the plant with milk receiving by bulk than for the plant with milk received by can. [6] Other equipment, needed for either can or bulk receiving of milk, includes pump, clarifier, sampling and recording equipment, sanitary pipe and fittings, coldwall storage tank and plate cooler. [7] Investments for plants included in detailed cost surveys, with investments as reported for 1946 and 1948 adjusted to reflect changes in factor costs to 1952. These plants were located in the Pacific Northwest except where otherwise noted. [8] This plant located in a metropolitan area in the Midwest.

Based on data in Appendix table 25.

Cost of Receiving and Cooling Milk

The cost of receiving and cooling milk is reported to range considerably less for bulk than for can receiving systems at milk plants and country receiving stations (26, 28, 75, 102, 103, 104, 152, 320). Cost of handling milk in bulk has been estimated to range from about 5 to 25 cents per hundredweight less than the cost of can receiving at small or medium-volume plants, about 12 to 22 cents per hundredweight less at large-volume plants, and about 4 to 16 cents per hundredweight less at very large-volume plants (4).

For each plant capacity there is a rather wide range of differences in cost between the two receiving systems. This is attributable in part to the variation in cost reported for can-receiving systems, both within regions and among regions (table 7). Type of plant operation as well as size of plant also contributes to the variation in cost, since the cost of receiving milk has been reported in both Midwest and Northwest (28, 221, 234) to range considerably higher at country receiving stations than at city fluid-milk plants (table 8).

TABLE 7.--COST OF RECEIVING AND COOLING MILK BY CAN AND BY BULK

Can

Region	Cost of receiving and cooling milk at plants with intake capacities of:			
	200-399 cwt.	400-599 cwt.	600-999 cwt.	1000-1640 cwt.
	Cents	*Cents*	*Cents*	*Cents*
Northeast................	9.5	10.8	--	--
Midwest..................	9.0	25.1	17.8	9.4
Southeast................	12.4-26.8	--	--	--
Northwest................	31.8-40.3	27.6	24.1	18.6

Bulk

Region	200-399 cwt.	400-599 cwt.	600-999 cwt.	1000-1640 cwt.
Northeast................	3.3	--	--	--
Midwest..................	--	3.1	2.5	2.3-4.9
Southeast................	--	--	--	--
Northwest................	7.6-11.3	--	6.3	5.6

Based on data in Appendix table 26.

The tendency for receiving costs to decrease with increases in volume is, in some studies of existing plants, obscured by various factors, such as degree of flexibility in use of the plant labor force (320), plant size, number of shifts daily, and milk volume (26). In other studies, of technically efficient plants of various sizes, receiving costs decreased with increasing capacity, although there were wide variations reported in the level of cost of receiving milk. For Northwestern plants, in studies by the Washington and Idaho Agricultural Experiment Stations (28, 320), variations in the cost of receiving milk by can are explained in part by differences in allocation of certain fixed-costs, lower refrigeration costs for the butter-powder plants than for the fluid-milk plants, and the use of a wage rate for plant labor twice as high at the fluid-milk plants as at the butter-powder plants. The labor costs at the Northwestern butter-powder plants were closely in line with those used in Midwestern, Southeastern, and Northeastern studies (26, 75, 258, 327).

TABLE 8.--ESTIMATED COST OF RECEIVING AND COOLING MILK BY BULK AND BY CAN AT MILK PLANTS AND COUNTRY RECEIVING STATIONS, MIDWEST AND NORTHWEST

Item	Cost and saving for receiving and cooling milk at plants with intake capacities of--			
	200-399 cwt.	400-599 cwt.	600-999 cwt.	1000-1600 cwt.
Midwest				
	Cents	*Cents*	*Cents*	*Cents*
Can-receiving	9.0	25.1	17.8	9.4
Bulk-receiving	3.3	3.1	2.5	2.3-4.9
Saving	5.7	22.0	15.3	7.1-4.5
Northwest				
Can-receiving	31.8-40.3	27.6	24.1	18.6
Bulk-receiving	7.6-11.3	6.9	6.3	5.6
Saving	24.2-29.0	20.7	17.8	13.0

Based on data in Appendix table 26.

Receiving costs per hundredweight of milk vary much less with volume in bulk receiving than in can receiving systems. This reflects not only a low level of fixed cost with bulk receiving, as expected from the reduced equipment investment (table 6), but also savings of substantial amount in variable costs (table 9).

The savings in fixed cost are a small proportion of the total savings with bulk handling, and range from about one-tenth to about one-third of the total. The amount of potential savings is least for very large or very small plants. For the smallest size group of plants, about 100 to 300 hundredweight daily volume, the fixed cost of receiving and cooling milk may increase by as much as 3-1/2 cents per hundredweight, or may decrease as much as 9 cents per hundredweight (4).

Variable costs represent the main savings in receiving cost, with the range of possible savings increasing as plant size decreases (table 9). The amount of savings in variable cost ranges from about 4-1/2 to 14 cents per hundredweight for large and very large plants, about 15 to 17 cents for plants of 380 to 420 hundredweight daily volume, and from a fraction of a cent increase to about 20 cents per hundredweight saving for the smallest size group of about 100 to 300 hundredweight per day.

Variable costs of receiving and cooling milk include refrigeration, utilities and supplies, and labor. Refrigeration offers the possibility of a small cost saving per unit of milk, and utilities and factory supplies, a somewhat larger though yet a moderate saving, consisting mostly of steam, water and factory supplies saved at the can washer and in cleanup of the receiving room. Labor represents a cost saving of substantial amount. The relative importance of refrigeration, utilities and supplies and labor as small, moderate and large components of the total savings is similar for industry reports covering plants in Northeastern, Midwestern, and Pacific coastal cities (30, 34, 115, 215), and for studies at agricultural experiment stations in the Northeast, Midwest, and Northwest (26, 28, 41, 75, 221, 327).

Refrigeration

Refrigeration is needed to cool the milk promptly after it is unloaded at the plant, unless the milk is to be pumped directly to the pasteurizer, and to cool the milk product

TABLE 9.--ESTIMATED FIXED AND VARIABLE COST OF RECEIVING AND COOLING MILK BY BULK AND BY CAN AT MILK PLANTS AND COUNTRY RECEIVING STATIONS, MIDWEST

Cost or saving	Cost for receiving and cooling milk at plants with intake capacities of:			
	200-399 cwt.	400-599 cwt.	600-999 cwt.	1000-1600 cwt.
Fixed cost				
Can	1.8	6.1	4.6	2.0
Bulk	1.0	0.9	0.5	0.3-1.3
Difference	0.8	5.2	4.1	0.7-1.7
Variable cost				
Can	7.2	19.0	13.2	7.4
Bulk	2.3	2.2	2.0	2.0-3.6
Difference	4.9	16.8	11.2	3.8-5.4
Total cost				
Can	9.0	25.1	17.8	9.4
Bulk	3.3	3.1	2.5	2.3-4.9
Difference	5.7	22.0	15.3	4.5-7.1

Based on data in Appendix table 26.

after pasteurization and processing. Refrigeration accounts for a major portion of plant cost for electricity and power, ranging from three-fourths to nine-tenths (26, 75, 156) of the total electricity cost in studies for Northeastern and Midwestern milk plants.

The refrigeration requirement has been shown, as expected, to increase with the temperature of the milk arriving at the plant (26, 28) and with the quantity of milk, both within plants and among plants (Appendix table 27). For small and medium milk plants, electric power consumption for refrigeration has been found to average about one-third lower for bulk as compared with can receiving; total electricity and power consumption for the entire receiving operation about two-thirds lower for bulk than for can receiving.

Utilities and supplies

Large quantities of utilities (electricity, fuel, water) and factory supplies are needed for milk receiving and other plant operations. Electricity is used in the operation of motors and lights as well as for the refrigeration system. Fuel is used in heating the milk during processing, in manufacturing steam, and in heating water for cleanup. Factory supplies are used, along with steam, water and much labor, for cleaning floors, equipment, and piping.

For small and medium plant capacities (about 100 to 420 hundredweight daily), the cost of electric power and light is one one-half as large for bulk receiving as for can receiving, for factory supplies about one-third as large for bulk as for can systems, and for steam about one-twentieth as much for bulk as for can receiving. For large and very large plant capacities the patterns are similar but the saving in cost is only moderate (Appendix table 28). For larger plants, savings range, for electric power and light, about 1/4 cent to 1-3/4 cents per hundredweight; for factory supplies, 1/2 cent to 1-1/2 cents per hundredweight; and for steam, about 4 cents to 8 cents per hundredweight. The larger

saving for steam than for power or supplies results from eliminating the washing of the cans in which the milk is received from farms.

The potential saving in utility expenses from converting a milk plant from can to bulk receiving is larger than could be achieved either by doubling of milk volume at any level of plant capacity (plant size unchanged), or by tenfold increase in both milk volume and plant capacity (with level of use unchanged) from 100 to 1,000 hundredweight daily.

Labor

The amount of labor expense saved in changing milk plants from can to bulk receiving is affected by the wage rate and the amount of labor saved. Hourly wage-rates of receiving-room labor ranged from about $1.10 to $2.75 per hour in the various studies for the Northeast, Midwest and Northwest (26, 28, 75, 320) and wage rate patterns vary broadly by area, and by city size. Lest variations in wage rate might conceal important variations in labor costs, comparisons of can and bulk receiving are best made in terms of labor requirements. The amount of labor saved with the shift from can to bulk operations varies with size of plant, milk volume and the degree of efficiency with which labor in the receiving-room was formerly being utilized under can operations. The limited studies comparing labor costs for can and for bulk operations at the same plants (28, 327) can be supplemented with comparisons based on studies and industry costs of bulk-receiving operations (26, 107, 115) and studies of can-receiving operations for the Northwest, Midwest, Northeast, and Southeast (107, 133, 148, 223, 258, 277, 320).

The amount of labor (4) that could be saved in converting milk-receiving operations from can to bulk ranged from about 1/3 of a minute to about 3-1/2 minutes per hundredweight for plants of various sizes, and was greater at smaller plants (table 10).

TABLE 10.--LABOR REQUIREMENTS AT MILK PLANTS FOR CAN AND BULK MILK-RECEIVING OPERATIONS

Region	Labor requirement[1] for receiving milk at intake capacities of:			
	Less than 200 cwt.	200-399 cwt.	400-1199 cwt.	1200-1599 cwt.
Bulk				
	Minutes	*Minutes*	*Minutes*	*Minutes*
Northwest	---	0.91-0.96	0.75-0.76	0.69-0.74
Midwest	---	---	---	.6
Northeast	---	---	---	---
Can				
Northwest	3.7-4.4	3.0-3.4	0.9-3.4	0.7-2.5
Midwest	1.9-2.3	0.9-1.8	0.7-3.3	1.3-1.7
Northeast	2.0-4.1	0.6-1.2	---	---
Southeast	0.6-4.8	---	---	---

[1] Minutes per hundredweight.

Based on data in Appendix table 29.

The savings amounted to about 10 man-hours per day for a large plant, 5-1/2 to 35 man-hours per day for medium plants, and about 2 to 20 man-hours per day for the small plants. Obviously some of the medium and small plants make inefficient use of receiving-room labor.

The labor requirement for bulk receiving averaged about one-third to one-fourth the requirement for can receiving, for small and medium plants; about one-half to one-third the requirement for can receiving in large scale operations. This compares with industry reports that man-hours for bulk receiving averaged one-fourth to one-half that for can operations in large-scale plants in the Pacific States (115).

For small- and medium-capacity plants with relatively efficient utilization of labor in present can receiving-rooms, the opportunity for saving in labor cost would be less promising. Labor is ordinarily hired for full-day or full-week work periods, and the fractional man-days of labor that could be saved at the receiving room by shifting to bulk receiving would need to be shifted to productive labor in other plant operations, if the shift were to reduce labor expense as well as labor requirement.

Dairy Waste Disposal

The cost of treating and disposing of dairy waste is an item of growing importance to many dairy plants. In 31 States specific laws regulating stream pollution were reported in 1955, and in many States and counties, additional pollution-control laws and regulations were being enacted, or those already on the statute books being more rigidly enforced (168, 316, 321). Dairy plant waste is an important factor contributing to stream pollution, because the oxygen from 1,600 gallons of normal, unpolluted stream water is required to decompose the organic matter in 1 pint of milk (88).

The loss of milk in bottling plant operations has been reported to range from 1.4 percent to 4.1 percent for various plants, and losses of about 1 to 2-1/2 percent of milk handled are considered reasonable operating losses in the industry (37, 117, 168, 186, 187). Milk solids content of the plant sewage is only one-sixth as large for bulk as for can receiving, for the amount of container rinsings from several tank trucks averages much lower than for hundreds of cans (88, 299, 318).

The amount of milk solids contributed to the plant's total dairy waste from the milk-receiving operation ranged from about 0.3 to 3.0 pounds per hundredweight of milk, (table 11). Milk loss from can stickage ranged from 0.4 to 3.1 pounds per hundredweight, but with bulk receiving no more than 0.1 pound of milk need be lost per hundredweight (252). Milk losses at dairy plants now receiving by can average much larger than minimum-loss standards used in engineering design of dairy plants (75, 114, 186, 187, 273, 274, 308). The loss of milk in the receiving room, though not so large as the loss due to processing shrinkage or route returns, (table 11) is somewhat more controllable by plant

TABLE 11.--MILK LOSSES AS DAIRY PLANT WASTE AT MILK-RECEIVING STATIONS AND MILK-BOTTLING PLANTS

Source	Range in amount of loss reported in:		
	Northeast	Midwest	Southwest
	Percent	*Percent*	*Percent*
Receiving-room	0.6-3.1	0.2-0.8	0.3-0.4
Processing	0.75-2.25	---	---
Total operating	[1] 2.5-3.5	---	---
Route returns	2.75-4.63	---	---

[1] Minimum loss standards for total operating loss with whole milk and cream ranged 0.35 to 1.65 percent for typical bottling plants in the Northeast (75).

Compiled from industry sources and reports of the Vermont, Delaware, Virginia, Wisconsin, and Oklahoma Agricultural Experiment Stations.

management (211). The draining time of the cans at the dump vat affects the amount of milk lost from container stickage. Increasing the length of time the cans are allowed to drain would of course slow down the rate of can-dumping, unless the can conveyor to the washer is lengthened and an extension trough provided underneath the conveyor to catch drippings from the cans moving away from the dump vat and to conduct the recovered milk back to the dump vat (274). This procedure has been claimed to recover 95 percent of the drainable milk in the can, in limited laboratory tests. Extensive tests under usual operating conditions at larger-than-average commercial dairies in Pennsylvania showed the amount of milk so recovered amounted to only one-sixth of 1 percent of total milk receipts, much less than average daily plant loss (250). Thus converting from can-receiving to bulk-receiving appears to offer greater reductions in receiving-room waste than can be obtained by modifying equipment or adjusting the rates of operation in existing can systems.

The importance of reducing the amount of milk plant waste is illustrated by the cost of adequate waste material treatment facilities. For a plant of 1,000-hundredweight daily milk volume, such facilities would cost $30,000 to $50,000 for conventional systems; $10,000 to $15,000 for "improved" systems of more recent design (186, 187). While converting a plant to bulk will not eliminate the need for treatment facilities, it will reduce the volume and strength of plant wastes, thus permitting use of a smaller treatment system, and less expense for electricity and labor, than would be needed with can receiving.

Increased Plant Capacity, Milk Volume, and Flexibility in Operations

The saving obtainable by installing bulk receiving at a milk plant may exceed that obtainable from increased volume at existing can-receiving plants, and cost per hundredweight will vary less with changes in volume with bulk than with can receiving. Large variation with changes in volume have been reported for can-receiving cost per cwt.[5] in studies of Northwest plants by the Washington Agricultural Experiment Station, Northeastern plants by the Virginia, Pennsylvania, Cornell, and Maryland Agricultural Experiment Stations (28, 30, 75).

Sources of the differences in costs between milk plants receiving milk in bulk and those receiving by can, in addition to the difference in method of receiving, include the effects of increased plant capacity along with the shift to bulk handling, and of changed milk volume relative to capacity.

Receiving costs for can operations were found to range much higher than for bulk receiving in a Northwest study (fig. 1).

The total cost of receiving and cooling milk is less for bulk than for can operations at similar capacity and milk volume. For either can or bulk receiving, cost is lower for larger volume and plant size (upper panel). Although main saving with bulk receiving is in labor cost, savings in fixed cost are substantial (middle panel). The total costs of receiving and cooling milk in bulk are about the same as the fixed cost with can equipment (lower panel). Opportunity for additional savings by reorganizing functions, so as to utilize labor more efficiently as plant capacity and volume are increased, is an additional advantage sometimes claimed for bulk receiving. That plant labor is often unproductive and inefficiently used has been reported in studies by State Agricultural Experiment Stations in both the Northeast, by Carter, Brundage and Bradfield, by Metzger, and by Scott; and in the Midwest, by French, Wood and Manhart, and by Hall (69, 133, 145, 146, 210, 277).

[5] In the Northeast study receiving costs decreased from 18.3 cents per hundredweight to 10.8 cents per hundredweight as daily volume increased from 40 percent to 100 percent of capacity, or from 150 hundredweight to 320 hundredweight at an individual plant (75). In the Maryland study, throughout a range from small (260 hundredweight) to very large (1,030 hundredweight) plant capacities, costs increased 25 percent with a 30 percent decrease in volume, 55 to 60 percent with a 50 percent decrease in volume (30).

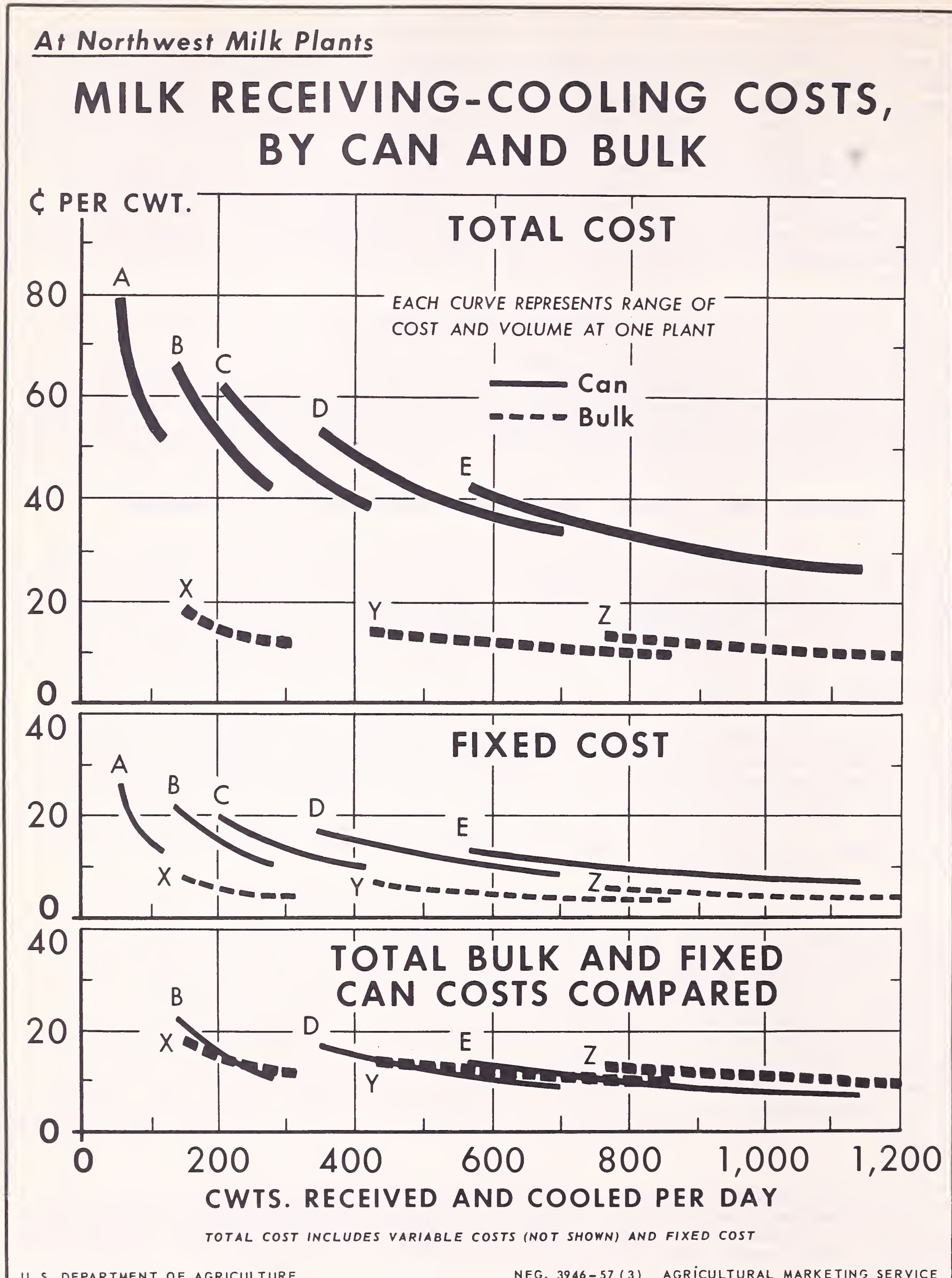
At Northwest Milk Plants
MILK RECEIVING-COOLING COSTS, BY CAN AND BULK
¢ PER CWT.
TOTAL COST
EACH CURVE REPRESENTS RANGE OF COST AND VOLUME AT ONE PLANT
Can
Bulk
A
B
C
D
E
X
Y
Z
0
20
40
60
80
FIXED COST
TOTAL BULK AND FIXED CAN COSTS COMPARED
0
200
400
600
800
1,000
1,200
CWTS. RECEIVED AND COOLED PER DAY
TOTAL COST INCLUDES VARIABLE COSTS (NOT SHOWN) AND FIXED COST
U. S. DEPARTMENT OF AGRICULTURE
NEG. 3946-57 (3) AGRICULTURAL MARKETING SERVICE

Figure 1

Other important savings may result from greater flexibility of daily time schedules in receiving milk, and flexibility in number of days' operation per week.

Milk handled by can is of course cooled at the farm, although the rate of cooling may be less rapid and the temperature of the cooled milk may be somewhat higher than for milk cooled in bulk. Where assembled by can farm to plant, additional cooling of the milk is necessary immediately on receipt at the plant, except of course for the relatively small proportion of the milk pumped directly into the processing lines as received. With milk handled by the can system, as much as possible of the total milk is assembled and received during the relatively cooler, early-morning hours of the day to minimize the rate of increase in bacteria count that commences soon after milking.

Where assembled farm-to-plant by bulk tank, the milk, already cooled at the farm, can be pumped directly to storage vats with little or no additional cooling, on receipt at the plant. And the milk can be assembled from farms or received at the plant any time of the day or night.

Further, although can-receiving operations with one man are feasible from small- to fairly large-scale milk receiving, usual practice in all but the smallest plants ordinarily is to assign crews of at least 2 and as many as 3 or 4 men, at least for peak hours daily, to the tasks of handling, dumping and washing cans, weighing the milk and drawing samples, maintaining records and cleaning the receiving room and equipment. The daily operations of these plants ordinarily must be scheduled to coincide with or overlap much of the milk-receiving schedule; otherwise receiving-room labor can not be so efficiently utilized by being shifted to other tasks when the milk trucks arrive at irregular intervals or after the peak receiving period. With bulk assembly, "the milk can be on hand for a 6 o'clock start or spaced for a 24-hour operation," according to an official of a large midwestern cooperative milk plant (242), and of the plant labor force only the 1 man who checks weight and draws check samples need be on hand at the time of unloading the tank trucks.

At any time of the day or night, the milk route driver can pump the milk directly from the truck tank into plant storage, and can rinse out the truck tank, using properly safeguarded connections located outside the main plant building. These connections may be closed and locked when the work crews are not on duty.

Where handled farm-to-plant by can, the milk must be collected from farms daily and must be "received" every day at a country station or city plant, so the milk can be cooled promptly to protect its quality. Where the milk is handled farm-to-plant by bulk, the milk is cooled at the farm to a temperature customarily considered "safe" for holding the milk for several days if necessary. In many markets when the collection of the milk every-other-day has become an accepted practice, the milk plants are able to arrange a 6-day or even a 5-day week operation (118, 137, 190, 337). Savings of about 3 cents per hundredweight through shifting from every-day to 6-day operations at bulk milk plants in the Northeast have been reported for both small and large daily milk volumes (41, 118).

High Cost of Dual Receiving of Both Can and Bulk Milk

Dual, or part-can and part-bulk, receiving operations accompany at least the early or transitional phase of converting an area's milk market structure from can to bulk (99, 102, 103, 104, 332). For example, about three-fourths of the milk plants receiving bulk milk in the Chicago, Ill. market in 1956 were still equipped to receive by can as well. In the Chicago market area total milk plants have decreased slightly in the past 3 years along with the shift in plant receiving equipment from mostly all-can facilities to mostly dual or combined can-and-bulk facilities (fig. 2, left). The number of market outlets for can shippers has decreased moderately, and outlets for bulk shippers have increased substantially. The number of plants equipped as market outlets to receive milk from bulk shippers is now about the same as the number equipped to receive milk from can shippers (fig. 2, right).

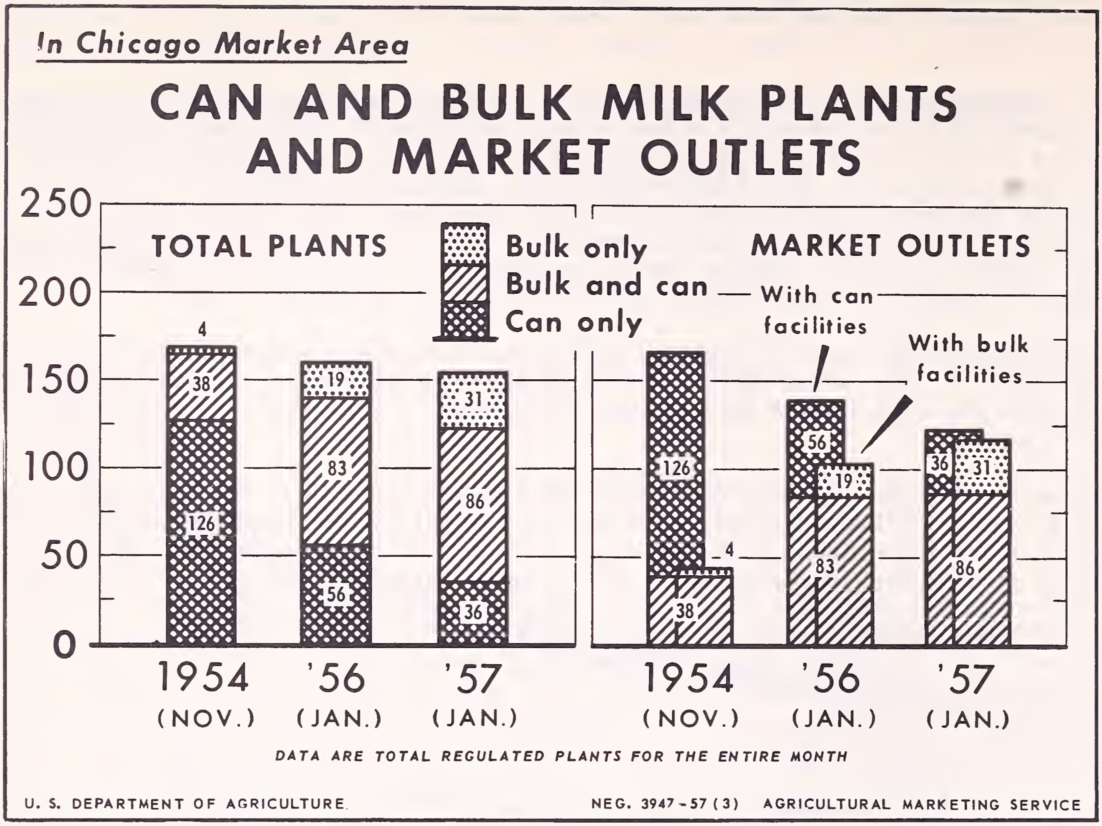

Figure 2

Plants with dual receiving represented three-fourths or more of all plants equipped to receive milk by bulk in each year, but dual plants increased from one-fourth to three-fourths of all can plants.

The operation of dual receiving lines is reported by some to reduce, by others to increase the cost of receiving milk above that for either all-can or all-bulk receiving. Beal reports that handlers receiving 40 to 80 percent of their milk in tankers may be unable to reduce manpower for receiving milk, resulting in increased labor cost per hundredweight (30). However, at one Midwest plant with large daily milk volume, the addition of a bulk milk-receiving line to supplement the can-receiving operation was reported to reduce both cost and labor requirements by relieving the can washing operation (65, 215). For the labor saved at the can washer to represent true cost savings, the labor would of course have to be productively used in other tasks, and this possibility is better with larger plants. And although research results show that some costs can be reduced in a dual-receiving operation as compared with all-can receiving, the saving is not so large as with an all-bulk operation. In a study of milk plant operations in the Midwest (296), Strain reported that so long as dual receiving lines had to be maintained, the maximum saving in receiving cost was only two-thirds to three-fourths as much as when all-can was replaced with all-bulk receiving. The cost of dual receiving was somewhat higher than for all-can and more than twice that for all-bulk receiving, so long as the volume received by bulk was less than one-fifth to two-fifths of total volume. It also has been claimed that as milk plants are converted to bulk receiving, small dairy plants are enabled to compete more effectively with large plants (65, 235). This seems probable only if small plants convert completely and large plants convert to dual receiving.

The higher cost of receiving and cooling milk at many plants with dual operations, and the small saving so long as any part of the milk supplies must be received by can at others, generate pressures on the plants to shift to complete bulk receiving and to eliminate can receiving entirely.

HOW BULK ASSEMBLY AFFECTS MILK HAULING

Bulk assembly of milk farm-to-plant offers opportunities for economies in milk hauling. With bulk handling, not only the amount charged to farmers for hauling their milk to plants, but also the method of calculating hauling charges, may be changed. The amount of adjustment in the charges and the type of change in hauling-rate structures may differ for can-haul and for bulk-haul milk collection routes. Patterns of ownership of the trucks and control of the milk collection routes may change as a result of differences in costs and in investment requirements. Changes in milk haulers' investments, operating costs, and route labor requirements encourage them to revise their hauling rates. The net effect of these factors includes some direct results of replacing can trucks and equipment with tank trucks and equipment, and some supplementary effects of the accompanying reorganization of routes.

Hauling Rates Charged to Producers

Rates charged to farmers for collecting their milk are generally less for bulk routes than for can routes, as indicated not only by nationwide surveys (80, 176, 294), but also by scattered reports from the Northwest, Midwest, Lake States, and Northeast (43, 77, 79, 129, 135, 147, 242, 300). The survey data obtained by Johnson, averaged by market for 35 large U. S. cities, showed average hauling charges to producers were lower on the bulk routes than for the can routes for three-fourths of the markets reporting. These markets were located principally in the Northeast, Midwest, and Southwest. The survey data obtained by Stocker, averaged by individual firms for 70 milk-buying firms, showed average hauling charges to producers had been reduced on the milk collection routes converted from can to bulk by 7 out of each 10 firms reporting, the same proportion as found by Cowden 3 years later also averaged by individual firms for milk-buying firms (table 12).

TABLE 12.--TYPE OF CHANGE IN AVERAGE HAULING CHARGES TO FARMERS ON MILK COLLECTION ROUTES CONVERTED TO BULK

Region	Firms reporting average hauling charges on milk collection routes after conversion to bulk as-					
	Lower		Unchanged or higher		Total	
	1953	1955	1953	1955	1953	1955
	Number	*Number*	*Number*	*Number*	*Number*	*Number*
Northeast	21	18	1	13	22	31
South	3	14	0	3	3	17
Midwest	17	34	11	21	28	55
West	15	21	6	6	21	27
United States	56	87	18	43	74	130

Compiled from survey data reported by U. S. Farmer Cooperative Service.

The surveys indicate also that the pattern and the amount of reduction in charges for milk hauling may be related to changes in actual costs. The amount of reduction in hauling rate varied among plants and markets, ranging 15 cents per hundredweight of milk, or less, in about two-thirds of the reports both by market (176) and by firm (80, 294). It has also been reported that little or no reduction in hauling rates has occurred in areas of concentrated milk production (31, 90, 132, 282) and relatively low-cost can-hauling, during the first several years of conversion to bulk assembly.

The pattern of changes in hauling rates with conversion to bulk handling varies not only among firms and among regions but also over time. This is illustrated by regional summaries of the data obtained by Stocker and Cowden (table 12). In 1953, for example, 95 percent of the firms in the Northeast, 60 percent in the Midwest, and 70 percent in the West, reported reduced hauling charges on bulk milk collection routes. In 1955, the proportion of Midwestern firms reporting lower charges on bulk routes was unchanged, but only 60 percent of the Northeast and nearly 80 percent of the Western firms reported lower charges on bulk routes. The number of firms reporting reduced hauling rates was about doubled in the Midwest, up slightly in the West, about the same in the Northwest. In the Midwest and Northeast there was a large increase from 1953 to 1955 in the number of firms reporting no reduction in hauling charges on routes converted to bulk handling. This may indicate that the milk plants and assembly routes with largest potential saving are most likely to be among those converting earliest to bulk, with the less profitable conversions occurring later.

The amount of saving possible in converting milk collection routes from can to bulk is of course directly related to the relative cost of route operations with can trucks and with tank trucks.

Changes in Milk Haulers' Investments and Costs

The cost of milk hauling equipment is higher for bulk than for can trucks of the same milk-hauling capacity (Appendix tables 30, 31). Three main factors account for the larger investment requirements: the higher cost of the tank and equipment compared with a van, the higher cost of the heavier truck chassis, and the larger size of truck used.

A truck tank is considerably more expensive than a can van. For example, it costs $3,000 or more to replace a 150-can van bed with a 1,500-gallon truck tank. Truck tanks of this capacity are reported to cost from about $4,000 to $6,500, van bodies from about $600 to $850. Investment in cans is not here included as the cans ordinarily are owned separately from the truck, by either the farmer or the milk plant.

The heavier chassis commonly used for a tank truck costs more than the lighter chassis commonly found on can vans. Trucks commonly used for hauling milk are reported to cost only $2,600 to $4,000 for capacities of about 110 to 150 cans, about one-sixth less than the $3,000 to $4,300 commonly reported for the tank-truck chassis.

Total investment in chassis and tank is reported to range about $8,300 to $10,300 for a 1,500-gallon tanker, compared with about $3,400 to $3,700 for a chassis and can van.

Larger trucks with larger load capacities are used on the routes from which milk is collected in bulk than with can (<u>220</u>, <u>299</u>). At the larger load capacities, the amount of extra investment per truck for replacing can units with tank trucks represents a smaller proportion of total investment. For example, total investment per truck, including chassis, tank and equipment, has been reported in Midwest commercial operations to average twice as large for bulk as for can at 1,500-gallon loads, but only about 1-1/2 times as large at 2,500-gallon loads (table 13).

<u>Truck operating costs</u>

Scattered reports indicate that truck operating costs per mile range about the same to somewhat larger for hauling milk by tank compared with can (table 14), for comparable truck sizes and loads. The saving in cost for bulk as compared with can hauling must, therefore, include some savings resulting from picking up larger loads of milk on the bulk route than on the can route, hauling more than one load daily, or from route reorganization.

Detailed analyses of truck costs for milk hauling by can and by bulk tank have been made in the Northeast, Midwest and Northwest (<u>27</u>, <u>41</u>, <u>72</u>, <u>79</u>) (table 14). In these studies, fixed cost per day ranged about one-third to two-thirds larger for most common tank

TABLE 13.--INVESTMENT IN TRUCKS AND EQUIPMENT, FOR CAN AND BULK MILK HAULING COMPARED AT TWO LEVELS OF DAILY MILK CAPACITY, MIDWEST.

Item	Unit	1,500 gallons		2,500 gallons	
		Can	Bulk	Can	Bulk
Number of trucks......................	Number	2	1	3	1
Total investment, truck and equipment..	Dollars	6,500	13,000	9,750	14,625
Investment requirement, compared with can...............................	Percent	100	200	100	150

Source: Industry reports.

TABLE 14.--COST OF OPERATING CAN AND TANK TRUCKS FOR COLLECTING AND HAULING MILK[1]

Dollars per day

Item	Cost as reported for:						
	Northwest[2]			Midwest		Northeast	
	Bulk	Can		Bulk	Can	Bulk	Can
Depreciation and interest.......	2.06	1.49	[3] 1.61	3.40	1.70	4.96	2.51
Insurance, taxes, and licenses..	.71	.52	.63	1.13	.76	2.00	1.00
Garage.........................	---	---	.82	.49	.49	.75	.75
Total fixed.................	2.77	2.01	3.06	5.02	2.95	7.71	4.26
Cents per mile							
Gas and oil....................	5.10	5.22	2.21	3.68	4.09	5.00	5.00
Tires and tubes................	1.51	1.49	1.53	1.42	1.32	2.76	2.30
Repairs and maintenance.........	4.08	4.29	7.54	4.13	3.13	3.56	3.56
Total variable.............	10.69	11.00	11.28	9.23	8.54	11.32	10.86

[1] Truck capacities: 1,500- 1,800-gallon tanks, 135-150 cans.
[2] Data for Washington, except as noted otherwise.
[3] Data for California.

Compiled and adapted from data in Appendix tables 32 and 33, and reports of the U. S. Farmer Cooperative Service.

trucks (about 1,500- to 1,800-gallon capacity) compared with most common can trucks (135- to 150-can capacities), as expected since investment per truck is larger for tank trucks. Fixed cost varied also with length of depreciation period, averaging highest in the Northeast. Variable cost per mile is closely similar for either can trucks or tank trucks, and ranged from about 9-1/4 cents for bulk and 8-1/2 cents for can trucks under Midwestern conditions, to 11-1/4 cents for bulk and 10-3/4 cents for can trucks under Northeastern conditions. While operating costs were not calculated for partial loads, Midwestern truck operators were reported (221) as considering operating costs per mile

about the same for trucks with full loads, partial loads, and without loads, since operating cost differs very little with changes in the weight of the load.

Operating costs per mile, as expected, are larger for larger-size and larger-capacity trucks. Truck costs for hauling in bulk are as much as 5.6 to 5.8 cents per mile more than for hauling in cans according to one report (41); but 0.7 to 0.8 cents lower according to another (79). The amount of savings in the per-hundredweight cost of hauling milk appears to depend in part on load size and route efficiency, and whether can hauling costs themselves are high or low. Truck costs--can or bulk--per hundredweight of milk are lowest if the truck carries a large volume per day and per load. They are also lowest at larger milk volumes per mile of route travel and per man-hour of route time.

Part of the advantage which bulk milk trucks have in hauling costs is attributable to differences in the net payload, amounting to about 10 percent more for bulk than for can. This amounts to more than one ton at 2,500-gallon loads. Disregarding the weight of an insulated van body, 250 milk cans of 10-gallon capacity weigh about 6,750 pounds compared with about 4,500 pounds for a 2,500-gallon truck tank. The 2,250 pounds saving in container weight represents about one-tenth of the weight of 2,500 gallons of milk.

Milk volume and mileage per load

Average volume per load and mileage per load are important factors affecting the hauling cost per hundredweight of milk. For example, a Midwest cooperative operating a fleet of trucks reported (63) that the cost of hauling milk in cans averaged 3.7 cents per ton-mile for straight-frame trucks but only 2.3 cents per ton-mile for larger semi-trailer loads. Truck operating cost per mile averaged less, however, for the smaller trucks, 21 cents compared with 27 cents for the semi-trailers (table 15). The lower cost per hundredweight with the larger trucks was a result of full loads in a larger proportion of total loads and total mileage. Other reports from Midwest plants (80) show interplant milk-hauling costs with full loads and 1,500-gallon trucks proportional to length of haul, averaging 10-1/4 cents per hundredweight for trips averaging 90 miles compared with 16 cents per hundredweight average for trips averaging 150 miles.

Average volume per load and per mile and mileage per load are important factors affecting the cost not only for interplant haul but also for collecting milk. This is illustrated by calculations for milk collection routes in the Pacific States reported by Clarke and by Baum (27, 73) and for Midwest routes reported by Cowden (80). For 3,500-gallon

TABLE 15.--VARIATION WITH TRUCK SIZE AND LOAD IN COST OF HAULING MILK BY CAN AND TANK, ONE TRUCK FLEET, MIDWEST

Type of unit	Number of units	Capacity	Average miles traveled per year	Average ton-miles per trip	Hauling cost		
					Per mile		Per ton-mile
					Truck	Total	Total
Can trucks	*Number*	*Gallons*	*Miles*	*Number*	*Cents*	*Cents*	*Cents*
Straightbed.....	17	---	16,164	3,499	13	21	3.7
Semi-trailer....	3	3,100-3,600	56,043	4,537	18	27	2.3
Tank trucks							
Semi-trailer....	19	2,650-4,200	45,975	---	15	22	---

Adapted from reports of U. S. Farmer Cooperative Service.

loads, truck cost ranged from one-half cent per gallon where the complete load was picked up in 50 miles of travel, to 1.2 cents per gallon for can loads and 1.1 cents per gallon for tank loads where 200 miles of route travel was required to complete the load (28). For 1,500-gallon tank loads, truck costs farm-to-plant averaged 19-1/2 cents per hundredweight for 119-mile route trips with 100 pounds milk volume per mile, 35 cents per hundredweight for 225-mile route trips with 50 pounds milk volume per mile (80).

For a particular truck capacity and route length, the larger the milk volume per mile, the less the truck cost of collecting the milk, and the larger the milk volume per farm, the less the labor cost of picking it up.

The relation between cost for hauling milk and the quantity of milk per mile and per farm was calculated for New England conditions by Bressler and Hammerberg (46) and by Johnson and Henry (177), for Pacific Coast conditions by Clarke (73) and by Baum and Pauls (27), and more recently for the Midwest by Cowden (80). The New England studies were limited to can hauling; the Midwest and Pacific studies included both can and tank hauling. For Connecticut, hauling costs were decreased 2 percent to 7 percent on some routes as milk volume per mile increased 10 percent to 50 percent. Hauling costs increased 2-1/2 percent to 22 percent on others with milk volume per mile decreasing 10 percent to 50 percent. In another New England study, an increase in average milk volume per farm was accompanied by a decrease in cost per hundredweight for each category of route costs--fixed truck expense, truck operating expense, labor--with total truck costs per mile increasing at a less rapid rate than the increase in milk volume per farm. In other studies, truck and labor cost for collecting and hauling the milk was found to be higher for bulk than for can hauling over the range of smaller milk volumes per farm, but lower for bulk than for can hauling throughout the range of larger milk volumes per farm. The cost advantage of bulk over can handling increased as volume per farm increased.

Total costs for the tank method fall off rapidly throughout the entire range of volume per farm stop, while costs for the can method level off at a relatively higher cost and at a relatively small volume per stop. These relationships were reported for the studies in California, Washington, and the Midwest. For example, in Washington, with milk collected on the bulk route every other day and on the can route every day, the cost of collecting, hauling and receiving full tank-truck loads, per hundredweight of milk, averaged $1.13 for can and $1.03 for bulk, where the average milk volume per farm was 100 pounds (1-1/2 cans) per day. The cost decreased to 45 cents for can and 29 cents for bulk at 500 pounds per farm; and to 43 cents for can and 24 cents for bulk at 800 pounds per farm stop (27). Volume picked up per farm stop was twice as large for bulk as for can hauling.

Frequency of collection

Collecting the milk every-other-day on bulk routes has become commonplace (80, 294). Among the firms that receive part or all of their milk by bulk tanker, firms reporting skip-a-day collection on at least part of the routes increased from about two-thirds to more than three-fourths of the total between 1953 and 1955; and in 1955 over half of the plants reported their milk was being collected every-other-day on all routes (79).

For a milk collection route where every-other-day collection replaces daily collection of the milk, milk volume per mile of total route travel may be increased substantially. Milk volume per stop doubled, and fixed time per hundredweight of milk was reduced substantially. Milk volume per farm stop is important because of the fixed time of about 6 to 15 minutes per stop for all the milkhouse operations with bulk hauling (27, 149, 234). The time required to perform these fixed operations varies somewhat with the ability of the driver to organize the work efficiently and to do it quickly but carefully (149, 301); still it amounts to only about half of total time per farm. Fixed time per farm is a much larger proportion of total farm time for small than for large producers. Pumping the milk varies as to time required, with the pump capacity and volume of milk picked up.

Meters and printer-recorders, discussed above (p. 12), could reduce the fixed time at the farm. The time used in weighing and sampling of milk, under conventional can receiving operations, ranged from about one-half minute to two-thirds minute per producer in one New England study by the Vermont Agricultural Experiment Station, and about one-fifth minute to 1-1/4 minutes per producer in Midwestern studies by the Michigan and Indiana Agricultural Experiment Stations (Appendix table 34). Time for weighing and sampling a tank-truck load of milk with bulk receiving and most efficient methods averaged about 8-1/2 minutes, including 5-1/2 minutes for check-gaging the tankload at the plant before receiving the milk, or 3 minutes for sampling and "weighing" (measuring, converting, and recording) the milk as picked up, without check-gaging at the plant.

Only the 0.87 minutes spent gaging milk at the farm, represents time for operations that cannot be combined with other necessary "receiving" operations, such as pumping off the milk or agitating it for sampling. Mechanizing the weighing or measuring and recording duties would eliminate the 0.87 minutes for "weighing". An automatic sampler would eliminate a minimum of 2 minutes for agitation. There would remain about 5 to 10 minutes for pumping the milk from the farm tank to the truck tank.

Comparisons of man-hours of labor required for collecting milk at farms, hauling, and unloading at plants have been calculated for the Pacific States by Clarke and by Baum and Pauls (table 16) (27, 72). The latter report no appreciable difference in driving time or in loading and unloading time between 1,500-gallon and 2,500-gallon tank trucks. Clarke analyzed time spent driving between stops and corresponding distances traveled but found that topography, traffic, road conditions and other factors obscured the effect of distance hauled, load capacity, and full or partial loads on time required (27). Hall reported somewhat less time required in the Midwest for preparing to unload and for cleaning the truck tank than Baum and Pauls found for Washington (149).

Route labor cost per hundredweight of milk is lower for skip-day than for every-day collection of the milk. Time required for fixed tasks in loading and unloading the milk is reduced relative to volume; and both mileage traveled per hundredweight and hauling time per hundredweight are usually also reduced with skip-day collection from farms. These factors contribute to the greater efficiency of truck and labor utilization reported by dairy plants for milk hauling by bulk compared with can (205, 301).

Reorganization of Milk Collection Routes

Efficiency of route operations can be further increased, and truck and labor cost per hundredweight of milk further reduced, by route reorganization accompanying the shift from can to bulk assembly. Clarke estimated savings of 25 percent in milk collection costs as being obtainable in shifting from daily to skip-a-day milk collection, and concluded "the real cost-saving potentials involved in every-other-day collection stem from the fact that increased volume per stop permits route reorganizations and makes larger load sizes feasible." (73)

Previous studies of milk assembly in the Northeast, Midwest and South[6] have indicated the possibility of substantial savings in costs through increased efficiency in the organization and operation of milk collection routes (76, 78, 79, 96, 137, 151, 196, 198, 201). Plant experience indicates considerable savings from route reorganization (94, 96, 222, 253). Estimates of the savings through route reorganization and consolidation ranged, for truck mileage, from one-tenth in Kentucky to about one-fourth in New Hampshire. The estimated increase in volume per load averaged about 30 percent, and the overall reduction in assembly costs about one-third to one-half (44, 45, 46, 106, 161, 197, 251, 255).

Changes in Route Ownership and Control

Are the savings in costs of collecting and hauling the milk from farms to plants retained by the haulers, or are they shared by haulers to some degree with farmers? It is

[6] The problem is not unique to these areas, nor even to the United States. E. g., Burton (61) reports similar savings potential from reorganization of milk assembly routes for the Montreal, Canada, milkshed.

TABLE 16.--SUMMARY OF FACTORS AFFECTING TIME REQUIREMENTS FOR TANK AND CAN MILK-ASSEMBLY ROUTES, PACIFIC STATES

Operation	Time required as reported for:							
	California				Washington			
	Per route	Per farm	Per gallon[1]	Per mile	Per route	Per farm	Per gallon	Per mile
Bulk routes								
	Minutes	*Minutes*	*Minutes*	*Minutes*	*Minutes*	*Minutes*	*Minutes*	*Minutes*
Loading[2]............	---	10.1	0.0167	---	---	8.5	2.3780	---
Unloading............	25.3	---	0.0167	---	110	---	2.2388	---
Driving............	---	---	---	2.727	---	---	---	---
Total............	25.3	10.1	0.0334	2.727	---	---	---	---
Can Routes								
			(per can)				*(per can)*	
Loading............	---	2.120	0.457	---	---	0.7	0.4408	---
Unloading............	---	---	0.237	---	15	---	0.2796	---
Receiving[2]............	---	0.261	0.206	---	---	---	---	---
Driving............	---	---	---	2.727	---	---	---	---
Total............	---	2.381	0.900	2.727	---	---	---	---

[1] Depending on pumping rate.
[2] Including measuring and recording milk volume, drawing samples for butterfat test and bacteria count, and record-keeping.

Compiled from reports of California and Washington agricultural experiment stations.

reported in many areas that rates charged to farmers for hauling their milk to market are commonly reduced during the early phase of the transition to bulk handling (80, 129, 176, 194, 234, 294). Surveys of all U. S. milk plants receiving at least part of their milk supplies in bulk showed that milk-hauling rates charged producers who ship by tank averaged lower for both every-day and skip-a-day collection than rates charged producers who ship milk daily by can (80, 294). The amount of change on individual milk collection routes ranged from rate increases of 3 cents to 10 cents per hundredweight, to rate reductions ranging from 2 cents to 20 cents per hundredweight (80).

The question of who shares in the cost savings, and in what proportion, depends in large part on whether the rates presently charged to farmers fully reflect the actual cost of collecting and hauling the milk. Rates charged to producers for collecting and hauling their milk often fail to reflect the full cost of operating the truck routes. Converting milk collection routes from can to bulk may afford the opportunity for adjusting hauling rates where charges had lagged behind changes in costs.

These factors in turn are affected by the degree of competition among haulers in establishing the hauling charges, and the relative bargaining position and strength of the haulers compared with farmers. One source of bargaining power is the ownership of milk collection routes, or their control by owners of the milk trucks (89, 100, 194).

To what extent are the changes in the rates charged to producers for hauling their milk under bulk assembly associated with changes in the ownership or control of the hauling routes? There has been reported the expectation that the milk plants adopting bulk receiving would tend to seek increased control of their milk collection routes through ownership of the tank trucks. Are the firms which previously used contract hauling with can assembly shifting to hauling in plant-owned tank trucks? The data reported by Cowden may be interpreted as indicating a possible tendency in this direction (80) (table 16). Other data show conflicting tendencies (tables 17 and 18). The number of tank trucks owned by milk plants more than doubled from 1953 to 1955, but the plant-owned tank trucks represented only one-third of the 600 total trucks in 1955 compared with about one-half of the

TABLE 17.--OWNERSHIP OF MILK TANK TRUCKS AND TRUCK TANKS, 1953 AND 1955

Region	Tank trucks: Plant	Tank trucks: Contract hauler	Tank trucks: Other	Truck tanks: Plant	Truck tanks: Contract hauler	Truck tanks: Other
1953						
	Number	*Number*	*Number*	*Number*	*Number*	*Number*
Northeast....................	18	19	2	([1])	([1])	([1])
South........................	3	25	1	---	---	---
Midwest......................	27	22	4	---	---	---
West.........................	42	16	6	---	---	---
United States............	90	82	13	---	---	---
1955						
Northeast....................	48	100	2	49	99	2
South........................	27	88	8	33	85	5
Midwest......................	52	145	2	66	130	3
West.........................	77	40	11	78	39	11
United States............	204	373	23	226	353	21

[1] Data not available.

Compiled from survey data published by U. S. Farmer Cooperative Service.

TABLE 18.--OWNERSHIP OF MILK CAN TRUCKS AND TANK TRUCKS BY MILK PLANTS WITH BULK RECEIVING FACILITIES[1]

Region	Can trucks		Tank trucks	
	Yes	No	Yes	No
1953				
Northeast	4	20	17	10
Midwest	1	6	3	5
South	15	25	23	14
West	13	14	19	7
United States	35	65	62	36
1955				
Northeast	9	23	8	24
Midwest	12	44	19	36
South	5	20	8	13
West	11	18	19	10
United States	32	105	54	83

[1] Number of firms: 1953, 98; 1955, 137.

Compiled from survey data reported by U. S. Farmer Cooperative Service.

185 total trucks in 1953. In 1955 there were about one-fifth more truck tanks than tank trucks owned by milk plants, both in the South and Midwest, and about one-tenth more for the entire U. S. Finally, among plants receiving part or all of their milk in bulk, the number of milk plants reporting ownership of either can trucks or bulk trucks was about the same in 1955 as in 1953, but the number of plants reporting that they did not own can trucks nearly doubled and the number reporting that they did not own tank trucks more than doubled, during this period (table 18).

Structure of Milk-Hauling Rates and Subsidies

Some indication of the relation between hauling charges and hauling costs can be obtained from the structure of hauling rates, especially the prevalence of (1) flat rates charged to producers regardless of milk volume or distance, and (2) payments by milk plants to farmers or to haulers, to cover part of the hauling cost. A hauling rate of uniform amount for all producers on the milk route was reported the most common hauling-rate structure for bulk routes by about one-half of the firms in a 1955 survey, and for can routes by about one-third (table 19). Firms reporting uniform rates regardless of distance or milk volume, as most common rate structure, comprised a smaller proportion of the total in 1955 than in 1953. Uniform rates were reported to be much more widespread among routes owned by milk plants than among those owned or controlled by contract haulers, for both can and bulk routes. Regionally, flat or uniform rates were most common on bulk routes for about one-half to two-thirds of the plants in the Midwest and West, about two-fifths to one-half of the plants in the Northeast and South. Flat rates as most common rate structure on can routes were reported for about 3 out of 10 plants in each region except in the South, where there were too few plants reporting for reliable comparison.

TABLE 19.--FREQUENCY OF UNIFORM RATES TO ALL PRODUCERS AS MOST COMMON HAULING-RATE STRUCTURE

Ownership of route or region	All firms			Firms reporting flat rate for hauling by:			Proportion of firms reporting flat rate for hauling		
	Can	Bulk		Can	Bulk		Can	Bulk	
		Daily	EOD[1]		Daily	EOD[1]		Daily	EOD[1]
	Number	Number	Number	Number	Number	Number	Percent	Percent	Percent
1953									
Company	18	29	31	9	20	23	50	69	74
Contract	60	22	19	19	12	7	32	55	37
Total U. S.	78	41	50	28	32	30	36	78	60
1955									
Company	29	33	84	12	22	51	41	67	61
Contract	90	43	79	22	18	35	24	42	44
Total U. S.	119	76	163	34	40	86	29	53	53
1955									
Northeast	27	18	44	8	8	21	30	44	48
Midwest	52	34	55	17	20	33	33	59	60
South	14	15	25	1	6	13	7	40	52
West	26	9	39	8	6	19	31	67	49
U. S.	119	76	163	34	40	86	29	53	53

[1] Every other day.

Compiled from survey data reported by the U. S. Farmer Cooperative Service.

Milk plants may pay a hauling allowance to milk haulers when the cost of operating milk collection routes goes up, rather than have the increased cost passed on to their farmers in higher rates. The practice of a milk plant absorbing part of the cost of assembling its milk supply is reported to be common in many areas (74, 78, 80, 302). The plant may underwrite a portion of the cost of collecting and hauling its milk by paying a subsidy on contract routes; but it may also subsidize milk hauling indirectly by setting rates below costs on routes which the plant itself owns. The extent to which firms owning and operating their own trucks may subsidize hauling in this manner cannot be measured from available data. Recent surveys show, however, that average rates charged producers on bulk routes were lower in nearly all States on routes owned by the milk plants than on routes owned by contract haulers (80), indicating either that company-owned routes may be more efficient or that rates may not fully cover the costs. So long as the milk producers converting to bulk assembly represent larger-volume producers scattered among routes of average can producers, there may be little saving because of too-high mileage per load. But, so long as the converted or potential bulk producers are located close together along compact and contiguous routes that can be serviced economically, as with route-by-route conversion, there may be cost advantages to plants that may warrant concessions to induce producers to shift to bulk. Such concessions commonly include reduced or subsidized hauling rates. Should the shift to bulk receiving continue unchecked, at some future time when the typical milk plant receives its entire milk supply from producers with bulk tanks, and when most dairy farmers of average or larger volume have converted to bulk handling, an individual milk producer would be much less closely associated with a change in plant cost or route cost, and less likely to receive concessions in price or in hauling cost as an inducement to shift to bulk. With less competition among plants for the more plentiful number of producers supplying bulk milk, the typical plant could build up its milk requirement from among available bulk producers without the necessity of concessions in price or in hauling costs. Thus hauling rates charged to farmers will more nearly reflect actual costs of milk assembly, depending of course on the negotiations among milk producers, and plants, and contract haulers.

What effect does progress in converting routes from can to bulk have on the possibility or amount of rate reductions? Effects differ for the new bulk routes compared with those established earlier, and for bulk as compared with can routes. Under unplanned or indiscriminate conversion, the early bulk routes formed by pirating larger producers from several can routes may be high-cost because savings with large volume per farm may be offset by too-high mileage per load. Reorganization of the earliest bulk routes as the shift to bulk proceeds would allow some further rate reduction. With successive reorganization, the potential further savings will decline progressively. For a route-by-route program of conversion to bulk equipment, progressively smaller reduction in rates with each route shifted from can to bulk is likely if the routes with the largest cost-saving potential are selected for converting earliest, for eventually the routes being converted would be those with little or no saving in hauling cost (31, 132, 221, 282).

As more routes in an area are converted to bulk, rate reductions become more likely on bulk routes, rate increases more likely on can routes. Hauling charges can be adjusted to changing operating costs more readily on both bulk and can routes after there has been substantial conversion to bulk. In the Pacific Northwest it was reported over a two-year period average cost for hauling milk had increased for cans, from 27 cents to 31 cents per hundredweight, but had decreased, for bulk milk, from 27 cents to 21 cents (80). The effect of converting to bulk on costs of operating both types of routes has been calculated for each stage of conversion to bulk for an entire Midwestern milkshed by French and Strain (table 20). There seems to be a tendency for hauling-rate structures to more nearly reflect factors affecting actual costs as routes are converted to bulk assembly. Scattered reports show an increasing number of rate structures on both bulk routes and can routes that include rate variation with distance hauled, volume per producer, and frequency of milk collection (92, 254, 331).

Because of the widespread occurrence of flat-rate hauling charges, the relatively low level of average hauling rates common on contract routes where the rate is set by open competitive bidding, and the payment by milk plants of hauling allowances to producers or

TABLE 20.--ESTIMATED CHANGES IN MILK-HAULING RATES CHARGED TO PRODUCERS AT VARIOUS PROPORTIONS OF BULK AND CAN HAULING, ONE MIDWEST MARKET, 1955[1]

Producers with bulk tanks as percent of all producers	Change in milk hauling charges to producers compared with original can-haul rates for --					
	Daily pick-up				Every other day pick-up	
	Bulk		Can		Bulk	
	Most efficient routes	Individual -Dairy routes	Routes consoli-dated	Routes Skeleton-ized	Most efficient routes	Individual -Dairy routes
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
5	207	394	4	5	56	147
10	---	---	11	12	19	57
25	40	77	22	35	-2	10
50	---	---	56	114	-7	0
75	17	34	177	252	-13	-6
100	24	34	---	---	10	-5

[1] Average volume per producer 232 pounds daily; actual level and seasonality of volume for each producer unchanged. Producers requiring bulk tanks under 100 gallons would not install tanks until after all large producers had installed them. Changes in hauling charges reflect changes in hauling costs.

Source: Reports of Purdue Agricultural Extension Service.

to haulers, the savings in hauling costs from converting from can to bulk assembly may not be fully reflected in rates charged to milk producers.

HOW BULK ASSEMBLY AFFECTS MILK PRODUCERS

The interest of dairy farmers in bulk assembly is in part a marketing problem, in part one of farm production and organization. Aspects of bulk assembly that affect milk producers and marketing both are particularly those affecting market functions (and their costs) that are shifted to the farm, milk volume sold and milk quality. With the shift from can assembly to bulk assembly milk producers may benefit from a slight increase in the amount of milk sold without any corresponding change in volume produced. The increase in the amount of milk for which producers are paid results in part from the reduction of milk and fat losses due to container stickage or spillage (p. 10). The cost of the milk lost as container rinsings, smaller in amount with bulk than with can assembly, is shifted from the farmer to the milk plant by the changed method of calculating producer payments. With milk handled by can, producers are paid for the amount of milk dumped into the weigh vat at the plant; with milk handled by bulk, for the amount calculated as being in the producer's tank when measured and sampled at the farm before the milk is pumped into the truck tank.

Other effects on dairy farmers of the shift to bulk assembly of milk may include improved quality maintenance in the milk sold by producers as indicated by bacteria count (p. 3), and the possibility of a reduction in the rates charged for collecting the milk and hauling it to the plant (p. 25,33). For the milk producer of average size or less, more than offsetting these small gains are (1) the possibility of increased electricity cost for cooling and handling milk at the farm, particularly where, with cans, only the night's milking was required to be cooled, (2) the substantial increase in his investment for milk cooling equipment, and related fixed costs, and (3) for many general farmers, the relatively

lower flexibility of milk production as one of several enterprises that could be expanded or contracted with changes in expected profitability. Bulk handling also affects the price to the producers for milk and the availability of market outlets.

Equipment Investments

For dairy farmers, the investment in the bulk tank ranges considerably higher than for present can-cooling equipment. Can-cooling equipment includes the milk containers as well as the cooler; with bulk systems, the farm tank serves as both cooler and farm container.

The investment in milk cans ranged from \$20.93 to \$27.63 per hundredweight of daily milk production, or \$18.00 to \$23.76 per 10 gallons of milk, in studies reported for the Pacific States and Midwest by Clarke, Baum and Pauls, and Miller (27, 72, 221). Can requirements varied by region and conditions of production in these studies.[7]

The amount of investment for the milk cooler varies, as expected, by type, design, and capacity of the cooler and by region (table 21). Investment requirements as compiled for studies in the Northeast, Midwest, South and West (tables 35 and 36, Appendix), range higher for bulk tanks than for can coolers; and among the bulk tanks, larger for the direct-expansion than for the icebank tanks of the same capacity. Icebank tanks require about the same investment as mechanical can coolers of the same refrigeration capacity; and can troughs in which the cooling medium is well or spring water cost least of all. For both icebank and direct-expansion tank coolers, total investment increases as capacity increases, but investment per unit of capacity decreases as capacity increases (79, 245) from \$9 to \$17 per gallon at 100-gallon capacities, to \$5.50 to \$7.50 per gallon at 500-gallon capacities (table 21).

For either system, can or bulk, the investment requirement for farm milk tanks tends to range highest in the Pacific Northwest and lowest in the Midwest, for comparable capacities. But variation within regions in investment requirement tends to be larger than variation among regions, largely because of the range of cost associated with the type of cooling system (direct-expansion or icebank), discounts, allowances for trade-in of can equipment, and installation costs.

Thus the amount of increase in investment for a dairy farm shifting from can to bulk cooling equipment is affected by the type of bulk cooler selected, the type of can cooler being replaced, and of course the amount of change in capacity. For many farmers the investment requirement will be twice as large to perhaps three times as large as for present can cooling equipment (5, 242).

In many cases of replacing can equipment with bulk the farmer must install new equipment anyway. Perhaps old can equipment may be worn out, the prescribed temperature at which milk can be received for fluid uses at the plant may have been lowered, the minimum time allowed at the farm for reducing the milk temperature to a prescribed level may have been shortened, or a new requirement made that milk from morning as well as night milking must be cooled at the farm. It has been reported, for example, that in order to comply with the temperature requirement in the model municipal milk code[8] that all milk be delivered at temperatures not exceeding 50° F., "the farmer will need refrigeration capacity for all the milk produced in one day and the use-cost of can coolers may increase as a result of the ending of double-loading of can-cooling equipment on farms" (242).

Where the farmer must install new equipment in order to meet more strict (or more rigidly enforced) sanitary regulations, he will not be able to consider cooling milk in cans

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[7] For large-scale drylot dairying in California, 3 cans were required for each 10 gallons (72); for the Northwest, 2 cans for each 10 gallons of peak-season milk volume (27); and for the Midwest, 1 can for each 70 pounds of annual average milk production for a seasonal pattern with a peak 40 percent higher than the annual average (22).

[8] 1953 U. S. Public Health Service Recommended Milk Ordinance and Code.

TABLE 21.--INVESTMENT IN CAN AND BULK EQUIPMENT FOR COOLING MILK ON FARMS

Capacity in gallons	Total investment reported for:			Investment per gallon for:		
	Pacific[1]	Midwest[2]	Northeast[3]	Pacific	Midwest	Northeast
Can Cooler						
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Cooler.............	850	600	837-875			
100 cans...............	222	336.50	222			
total.............	1072	985 - 936.50	1059-1097	10.72	9.36-9.85	10.59-10.97
cooler............	776	--- 1250	---			
200 cans...............	399.60	--- 488.40	---			
total.............	1175.60	1555 - 1738.40	---	5.88	7.78-8.69	---
Bulk Tank						
100....................	1750-2100	900-1680	1100-1700	17.50-21.00	9.00-16.80	11.00-17.00
200....................	2190	1600-2580	1700-2520	10.95	8.00-12.90	8.50-12.60
300....................	2502	2000-3100	2100-2890	8.34	6.67-10.30	7.00-9.63
400....................	2845	2500-3450	2490-3030	7.11	6.25- 8.63	6.23-7.58
500....................	3112-3750	2780-3790	2900-3320	6.22-7.50	5.56- 7.58	5.80-6.67
600....................	3421	3300-3400	---	5.70	5.50- 5.67	---

1 Washington, Oregon, and Idaho.
2 Chicago milkshed (Illinois-Wisconsin); Wisconsin-Minnesota; Iowa, Michigan, Minnesota.
3 Rhode Island, Vermont, Massachusetts, New Hampshire and Connecticut.

Source: Appendix tables 35, 36.

with a tank of well or spring water. His choice would be between cans and a mechanical can cooler, on the one hand, or a bulk tank, on the other.

The farmer's choice between a bulk tank or cans and a mechanical can cooler would involve as much as 50 percent difference in investment requirement (5). For example, for 200-gallon capacity, the investment ranges about \$1,560 to \$1,750 for cans and can equipment, compared with about \$1,600 to \$2,580 for bulk tanks. At the low side of the cost range, there is little difference in the investment required, between \$1,560 for cans and the lowest-cost can cooler, or \$1,600 for the lowest-cost bulk tank. At the high side of the cost range, the most costly bulk tank would require an investment, about 50 percent more than for cans and the most costly can cooler (\$2,580 and \$1,750, respectively). The same relationships may be found in investment requirements for milk cooling equipment at other capacities. At 100-gallon capacity, for example, investment for cans and can cooler range from about \$935 to \$1,100, compared with about \$900 to \$1,700 for bulk tanks.

Two hundred gallons represents a smaller-than-average capacity for a farm milk tank, while a 100-gallon cooler represents a larger-than-average can cooler. The tendency of milk producers to replace can coolers with bulk tanks of larger capacity adds to the amount of increase in investment in equipment for cooling the milk. Nevertheless, many farmers do replace their can coolers with bulk tanks of larger capacity. In some cases, expansion of the herd may have increased volume of milk to the point where the farmer's joint cooling-and-hauling cost would be lower by bulk than by can. In others, replacing a can cooler with a tank without an increase in volume might raise costs prohibitively. And in still others, replacing a can cooler with a tank at the same capacity might restrict the farmer to higher hauling cost with daily pick-up of the milk, whereas with a larger tank milk could be picked up every other day at lower hauling cost.

Farm Cost of Cooling and Handling Milk

On farms, the cost for cooling and handling milk is higher for bulk than for can systems, except for large daily milk volumes. With bulk cooling and handling, the labor requirement is somewhat lower, electricity cost about the same, and fixed cost substantially higher, compared with cooling and handling the milk in cans.

Labor

The labor cost of loading the filled cans into the milk cooler, and transferring the filled cans from the cooler to the milk truck, is eliminated with bulk handling. From among more than 100 farmers with bulk tanks in the Chicago milkshed in 1953, three-fourths reported labor savings for bulk compared with can handling of milk (259). For about one-third of those with some labor savings, the amount could not be estimated; for the remaining two-thirds (or about half of all farmers with bulk tanks) labor savings were reported to average 38 minutes daily, or about 0.6 man-hours per day.

Part of the labor saving reported may have resulted from reorganizing the milking-time work procedures; this is indicated by experiments at the Delaware and Oklahoma Agricultural Experiment Stations (24, 175) and by operating experience at commercial-scale dairy farms in the East and Midwest (31, 58, 152, 209). From the Delaware tests, Baker, McDaniel and Bondurant concluded that unless bulk tanks were used in combination with pipeline milkers, there would be little labor saved for a herd milked in a stanchion barn (24). From the Oklahoma tests, Johnson, Olson, and Von Gunten reported that the man-hours of labor used at milking time averaged considerably less for the days when the milk was handled by bulk than for days when handled with cans. However, their data also showed that man-hours used at chore time were considerably reduced from the first half to the last half of the test period in which the milk was handled by can (175). The commercial experience as reported for Eastern and Midwestern milksheds indicated that the man-hours of labor were reduced slightly, the number of cows handled per man increased, and the number of men needed for chore work was reduced on some farms but unchanged on others (31, 163, 164, 171). Herds ranged in size from 24 to 72 cows.

Electricity

Electricity cost is reported to be about the same or somewhat lower for bulk tanks than for mechanical can coolers of the same capacity, in reports from the Northeast and Midwest (150, 236, 310-313). Industry sources reported savings in electricity cost "from $1 to $8 per month, depending on the amount of milk shipped" in January 1952 and "substantial savings in electricity ranging from $1.50 to $6.24 per month, varying with size of farm and power rates" in March of the same year.

Replacing old, obsolete, or worn-out can-cooling equipment with more efficient new milk cooling equipment, can or bulk, would probably save some electricity because of more efficient performance. Nevertheless, the shift in milk cooling at the farm from can to bulk would in many cases be accompanied by an increase in the cooling capacity and result in higher total electricity use and cost (56, 101). More cooling with bulk would be needed also for a farm where morning milk handled by can had not been required to be cooled before being picked up, or where the regulatory agencies had lowered the maximum acceptable temperature for the milk on its arrival at the plant (164). The importance of electricity cost as an element of farm cooling cost appeared to vary considerably among farmers. Only three-fourths of those with bulk tanks in the Washington, D. C., milkshed had either an opinion about comparative electricity cost before and after installing the tank, or the receipted bills. Of those for whom electricity costs could be obtained or estimated, about one-fourth reported higher costs after the bulk tank was installed (31).

Electricity cost.--The cost of electricity for milk cooling may increase not only from higher consumption of electricity, but also from increased charges per kilowatt hour for the electricity used. Although electricity rates per kilowatt hour ordinarily decrease as consumption within the month increases, rates per kilowatt hour could be increased by a change in the rate schedule, or by the selection of a cooler that operated with a high power consumption in a short period of time at each milking and that would bring into effect a "demand charge" in the rate schedule. A demand charge is an extra or surcharge for kilowatt-hours of electricity used in excess of a prescribed amount within a measured period of time. The use of demand charges in the farm rate schedule is reported to have become a cost problem associated with bulk tanks on dairy farms in some Northeast and Midwest areas (19, 22, 70, 264, 282, 310). A possible alternative recently discussed, though not widely used, is the use of the higher, industrial rate-schedule, rather than the lower, residential rate-schedule, on farms where bulk tanks are installed. The net effect of either the shift to the industrial rate, or of a demand charge (whether a true surcharge or a fixed charge per horsepower of compressor capacity) would be to increase the cost of electricity per hundredweight of milk cooled.

In addition to the cost per unit of electricity used, the amount of electricity used varies widely with tank type, capacity and use (table 22). The amount of electricity used

TABLE 22.--ELECTRICITY USE FOR COOLING MILK BY TANK OR FARMS

Location of test	Electricity consumption per hundredweight for:			
	Icebank	Direct expansion		
		All	Air-cooled	Water-cooled
	Kwh	*Kwh*	*Kwh*	*Kwh*
New York................	1.6	0.9	---	---
Vermont.................	1.47	0.9	0.97	0.84
Michigan................	1.3-2.25	0.6-1.25	1.4-2.5	1.2-2.2

Compiled from data published by the New York (Cornell), Vermont, and Michigan agricultural experiment stations.

for cooling milk in farm tanks has been found to range lower for direct-expansion units than for icebank units in field tests conducted by State Agricultural Experiment Stations in the Northeast and Midwest (82, 150, 236, 282, 283, 284, 311, 312, 313, 322, 323, 335, 336), but consumption per hundredweight of milk varied widely and was affected by season, frequency of milk collection, level of use of the tank, and type of compressor.

Electricity use.--For direct-expansion tanks, 0.6 to 1.25 kilowatt-hours of electricity were used per hundredweight of milk in Michigan tests, and amounts within this same range were used in New York and Vermont tests (table 22). For icebank tanks, 1.3 to 2.25 kilowatt-hours were used per hundredweight of milk in Michigan tests, and again within this same range in New York and Vermont tests. Among direct-expansion units, 0.2 to 0.3 kilowatt-hours less were used per hundredweight for water-cooled compared with air-cooled compressors, but the consumption for water-cooled compressors averaged only 0.05 kilowatt-hours less in Michigan tests, compared with 0.13 kilowatt-hours less per hundredweight in Vermont tests. The Vermont data are affected to an unknown degree, however, by level of use and season. In the Michigan tests, more electricity was used in summer (0.85 to 1.25 kilowatt-hours per hundredweight) than in winter (0.6 to 0.9 kilowatt-hours per hundredweight) in a group of 6 tanks of both icebank and direct-expansion design.

In summer, though not in winter, electricity consumption per hundredweight of milk appeared related to the fullness of the tanks. Milk volume range from 20 percent to 40 percent of capacity (150).

Fixed cost

Fixed cost is by far the largest element in farm cost for cooling and handling milk. It represents the sum of all costs associated with the investment in equipment, including the farm tank or the can cooler and cans, together with the compressor and condenser. A part of the investment from which the fixed costs of bulk handling are derived may on many farms include the cost of necessary improvements in the milkhouse, farm lane, or wiring system. The amount varies greatly among individual farms. The elements comprising fixed cost are (1) depreciation, (2) interest, insurance and property taxes on undepreciated value, and (3) major repairs or renewals, which can be treated as fixed and their cost averaged over the entire useful life of the equipment.

For example, the costs of retinning milk cans and replacing can lids that are lost or damaged are major repair or renewal items. They are treated as fixed costs in studies reported by the agricultural experiment stations in the Midwest and West (27, 72, 221). In these studies, fixed cost for containers ranged from 1.0 to 1.5 cents per hundredweight of milk. (Appendix table 37.)

The amounts by which fixed costs per unit of milk increase with increasing amounts invested, and decrease as milk volume increases, has been calculated in studies at the Michigan, Indiana, and Illinois Agricultural Experiment Stations (130, 150, 319). Fixed costs for can coolers are lower for immersion coolers, ranging 2.0 cents to 3.8 cents per hundredweight capacity, than for mechanical coolers, ranging 3.6 cents to 4.3 cents per hundredweight capacity, including can costs. With a $1,500 investment in a farm milk tank, a dairyman would incur fixed cost of about 9 cents to 16 cents per hundredweight for 100- to 200-gallon tank capacities, with daily milk volume typical of the Lake States as found in a Michigan study (fig. 3, left). With the same $1,500 investment, a farmer with smaller and highly-seasonal milk volumes typical of southern Indiana dairying, would incur total cooling costs with farm tanks ranging higher than 25 cents per hundredweight with 100- to 200-gallon tanks, and 10 cents to 20 cents per hundredweight with larger tanks (fig. 3, right). Farm cooling costs are higher with pronounced seasonal variation in production and are lowest with even production.

The fixed cost per hundredweight of milk is affected by the amount of investment and by volume cooled. To some extent these factors may tend to offset each other. In an Illinois study, a $1,500 investment in a farm tank and 250,000 pounds of milk cooled annually

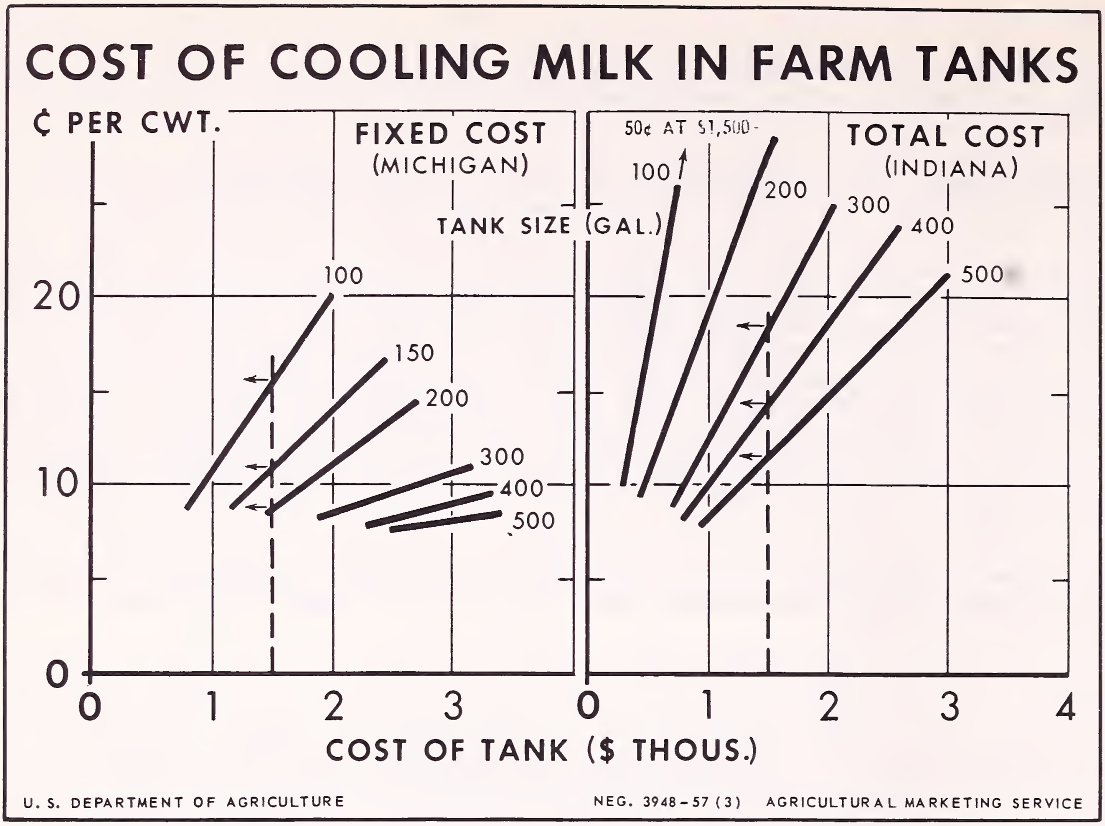

Figure 3

resulted in fixed cost of 6 cents per hundredweight (319). For the same investment, cost was lower at larger milk volume (fig. 4). The farms studied were typical of large-scale dairying in the milksheds of larger cities of the Midwest and Northeast.

Three main factors affect the fixed cost of cooling milk on farms. Fixed cost is higher with bulk tanks than with can systems except with large daily milk volumes. Fixed cost is higher for direct-expansion bulk tanks than for icebank tanks of the same capacity. Also, fixed cost is higher the lower the average use (table 23). Low average use may result from wide seasonal variation in production, skip-a-day collection of milk, or from the farmer's having selected too large a tank for the volume of milk.

At 200-gallon capacity, and with every-day collection of milk, fixed cost per hundredweight of milk capacity ranges from about the same to one-half cent higher for bulk tank than for mechanically operated can coolers (table 23). The extra cost of bulk tanks over can coolers is higher at smaller capacities, with fixed costs at 100-gallon capacity about 1 cent to 1-1/2 cents per hundredweight larger for bulk than for can coolers. Fixed cost for bulk tanks decreases rapidly with increase in capacity, from about 5 cents to 6 cents per hundredweight at 100-gallon capacity, to about 2 cents to 3 cents per hundredweight at 400-gallon capacity. At volumes larger than 300 gallons the cost advantage with every-day collection appears to be with bulk tanks rather than cans; in fact, fixed cost of bulk equipment for 300-gallon capacity ranges a fraction of a cent less than for 240-gallon can equipment (table 23).

Fixed cost, seasonal production, and frequency of milk collection. --Peak milk volume affects the level of fixed cost, by determining the capacity of the milk cooling equipment that is needed. Level of use of the equipment through the year causes fixed cost per unit of volume to vary from the potentially lowest cost. The lower the average

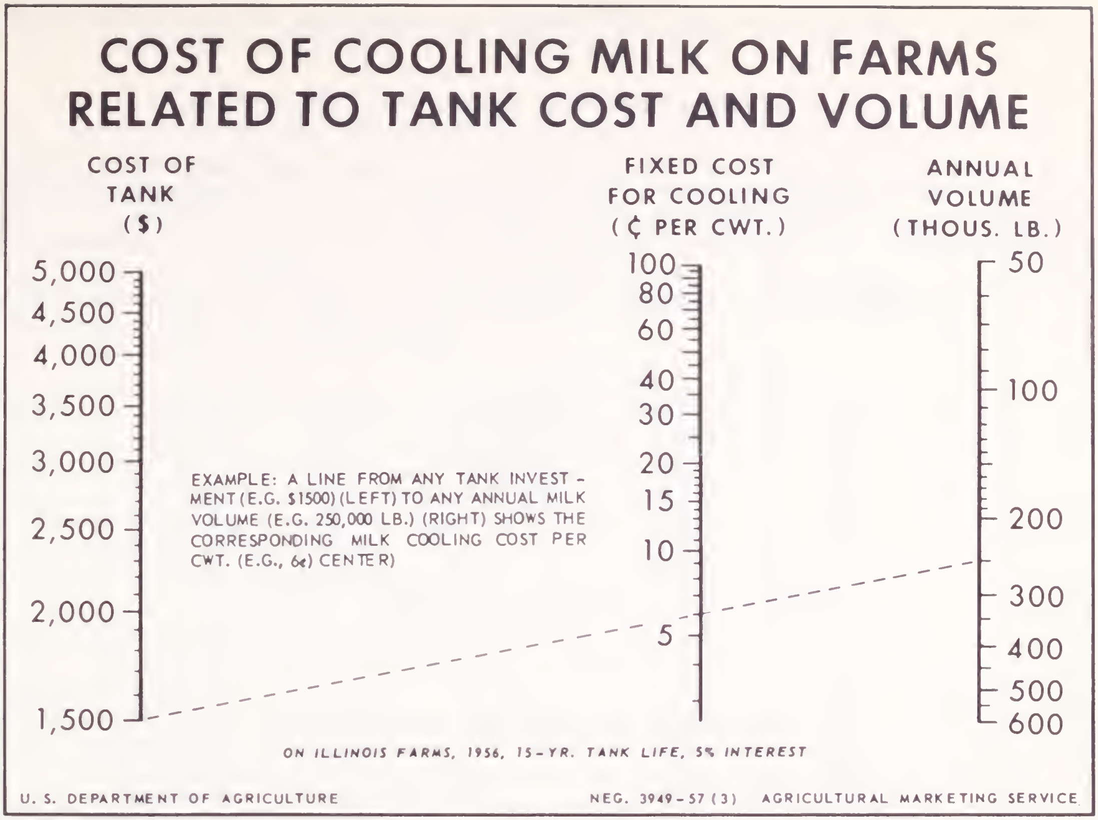

Figure 4

use of the tank, the higher the fixed cost per unit of milk cooled. The average use of the tank is affected by the level and seasonality of milk production and by the frequency of milk collection.

For a seasonal milk production pattern with a range of 40 points, which is a low range for many areas, daily fixed cost per hundredweight of milk cooled is about 25 percent higher than cost per unit of capacity. This pattern, ranging from about 80 percent of the seasonal average in the low month to about 120 percent in the peak month, is generally typical of seasonal milk production patterns found in a recent study of about 20 milk-producing areas supplying large-city markets in the Northeast and Midwest (160).

With skip-a-day collection of milk in bulk, which is the common practice in many areas, the milk volume cooled daily is no more than one-half of tank capacity. Where the daily volume is one-half of tank capacity, for example, 200 gallons of milk in a 400-gallon tank, and the milk is collected on alternate days, fixed cost per hundredweight of milk cooled is twice as large as it would be if the full tank of milk--400 gallons--were cooled daily and picked up every day. Fixed cost is not twice as high, however, with 50 percent use of a larger tank as with 100 percent use of a smaller tank. For 200 gallons daily volume, fixed cost ranges from 5.2 cents to 7.5 cents per hundredweight with a 400-gallon tank, only about one-fourth to two-fifths higher than the 4.1 cents to 5.2 cents for a 200-gallon tank.

For dairy farmers with 100 to 150 gallons daily milk volume, larger than "average" size for most markets, fixed cost for cooling the milk in bulk ranges about twice as large with daily collection of the milk, to about three times as large with skip-day collection, compared with handling the milk by can and mechanical coolers and collecting daily (table 23). For farmers with "average" daily volume or less, the spread in daily fixed cost between bulk and can cooling is even larger.

TABLE 23.--VARIATION WITH COOLER SIZE, MILK VOLUME AND FREQUENCY OF COLLECTION IN FIXED COST OF COOLING AND HANDLING MILK ON FARMS

Average daily milk volume in gallons	Cooler and container capacity			Daily fixed cost for milk cooling equipment		
	Bulk tank		Can	Bulk		Can
	Skip-day	Daily	Daily	Skip-day	Daily	
	Per hundredweight-capacity - 100 percent average use[1]					
	Gallons	*Gallons*	*Gallons*	*Cents*	*Cents*	*Cents*
100..............	200	100	93-116	3.3-4.2	4.9-5.8	3.5-4.9
150..............	300	150	150-160	2.3-3.3	3.3-4.6	3.0-4.2
200..............	400	200	200-240	2.1-3.0	3.3-4.2	2.8-4.1
300..............	600	300	---	1.7-2.4	2.3-3.3	---
400..............	800	400	---	1.6-1.9	2.1-3.0	---
	Per hundredweight-capacity - 80 percent average use[2]					
100..............	200	100	93-116	4.1-5.2	6.1-7.2	4.4-6.1
150..............	300	150	150-160	2.9-4.1	4.1-5.8	3.8-5.2
200..............	400	200	200-240	2.6-3.8	4.1-5.2	3.5-5.1
300..............	600	300	---	2.1-3.0	2.9-4.1	---
400..............	800	400	---	2.0-2.4	2.6-3.8	---
	Per hundredweight-volume - 80 percent average use					
100..............	200	100	93-116	8.2-10.5	6.1-7.2	4.4-6.1
150..............	300	150	150-160	5.8- 8.2	4.1-5.8	3.8-5.2
200..............	400	200	200-240	5.2- 7.5	4.1-5.2	3.5-5.1
300..............	600	300	---	4.2- 6.0	2.9-4.1	---
400..............	800	400	---	4.0- 4.8	2.6-3.8	---

[1] No seasonal variation in production.
[2] Skip-day collection at 80% average use equivalent to 40% of capacity with every-day collection.

Compiled from data in Appendix tables 38 and 39.

Fixed cost and increased milk volume.--The relationship of fixed cost to cooler capacity encourages producers shifting from cans to tanks to install the larger tank needed for skip-day collection and to increase milk production. For example, for a producer with peak milk volume of 150 gallons daily, fixed cost would range 3.8 cents to 5.2 cents with can, 4.1 cents to 5.8 cents with bulk handling. Fixed cost for bulk handling would drop to 4.1 cents to 5.2 cents at 200 gallons daily volume, and to lower cost levels at higher volume. In fact, daily milk production need be only doubled (from 150 gallons to 300 gallons) to keep fixed cost with daily collection in the same range with tank capacity increased fourfold, from 150 gallons to 600 gallons, and skip-a-day milk collection.

These calculations are consistent with the range of farm cost changes as presented in studies reported by the Oregon, Minnesota, Wisconsin, and Indiana Agricultural

Experiment Stations (95, 131, 132, 203, 221, 234, 296).[9] The range of herd size and milk volume varied.[10]

Shifts in Functions and their Cost

With the shift from can to bulk milk assembly, costs are changed not only because of new equipment but also because of changes in tasks. The principal costs affected by the shift to bulk handling are those directly related to type and size of equipment and to milk volume. As discussed above, both fixed and variable costs associated with equipment are generally reduced to milk plants and increased to farmers, over a wide range of milk volume and capacity. Also affected, and increasingly important in many areas, are the costs associated with the changed jobs.

With bulk handling, the receiving operation is shifted to the farm; its many tasks are shifted from plant laborers to the truck driver and the farmer. Most of the saving in plant labor and equipment cost because of the shift can be readily calculated. Only a part of the added labor and operating expense can be calculated for milk routes, and even less for farms. And, unlike the truck driver, whose compensation for his added responsibilities[11] with bulk handling includes a higher level of earnings or wages and perhaps a more stable wage structure, the farmer's compensation is not subject to his own control. With bulk assembly, the farmer bears the expense of complete cooling of both night and morning milk, in many cases to lower temperatures than formerly with cans. He bears the burden and cost of disposal of the dairy waste in container rinsings. This helps the plant in two ways: the quantity of dairy waste per producer is less with bulk than it had been for the same volume of milk in cans, and the waste is more widely dispersed when disposed of on the farms of the milk producers than when dumped by the dairy plant. Also the greater mobility of the bulk milk on the tank truck means that any plant is less dependent on any particular group of producers as a source of milk supply, for bulk milk by the tank truck load is already cooled, already mixed, and of more nearly uniform quality than milk in cans.

Are dairy farmers adequately compensated for the added investments and functions they assume with bulk assembly? Is the amount of net savings to producers, from the sum of changes in hauling charges and farm cooling cost, sufficient to amortize the farmer's large equipment investment and his operating costs for the new equipment and the added tasks? These are important questions and their effects are many. First, plant savings are likely to be reallocated as a result of negotiation among the milk buyers, haulers, and producers, the latter usually represented by their cooperative association. The basis for such negotiation has included not only the increased cost to farmers but also the shift in jobs from the plant to the farm. Second, number and size of producers are likely to change. Some small producers may shift market outlets from whole milk to manufacturing milk plants. Others may shift out of dairying. And dairy farmers who install bulk equipment may increase their production, especially for the normally slack months.

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[9] In these studies the conclusions were presented with the amount of change in farm cost shown as an item of the change in net cost to producers, as distinct from farm cost for milk cooling. The change in net cost to producers ranged from large total savings (12. 9 cents to 33. 5 cents per hundredweight, including unusually large labor savings) for Oregon producers, through small savings (4. 2 cents to 13. 5 cents) for producers in the Lake States, to moderate to large losses due to increased costs, ranging 25 to 30 cents per hundredweight for Indiana producers (95, 131, 132, 221). Changes in producers' net cost included lower hauling cost and, in two studies, the entire amount of plant-cost saving (95, 221), as well as the change in farm cooling cost.

[10] The Oregon study included a range of 10 cows to 100 cows per herd; the Minnesota study, 7 cows to 60 cows; the Wisconsin study included a range of 2 to 10 hundredweight daily milk volume (roughly 10 to 50 cows); the Indiana study, daily milk volume equivalent to require 100-gallon and 60-gallon tank capacities under Southern Indiana conditions (roughly 10 to 40 cows).

[11] The truck driver inspects the milk, measures its quantity, converts the measurement to volume, mixes the milk, draws and handles the samples, makes out and handles milk receipts, commingles the milk accepted from individual producers, in the process of loading the truck, unloads the milk at the plant, and for milk of questionable quality, either rejects the tankful or notifies the plant fieldman or producers' cooperative association fieldman to examine it (47, 112, 113, 180).

Effect on Milk Volume and Number of Producers

What are the differing effects of the shift to bulk assembly of milk on producers of various size? The foregoing cost analysis indicates that larger-volume milk producers stand to gain more from a shift to bulk assembly (or to see smaller increases in their costs) than smaller-volume producers. To the extent that costs determine the rate of shift to bulk milk handling on farms, bulk assembly can be an additional force in the trend toward larger-scale dairying that is evident in various studies (e.g. 207) and in the periodic reports of the Census of Agriculture. Also it appears reasonable to expect bulk producers to average larger in size and milk volume than can producers.

Data from recent surveys show that in every region, Northeast, Midwest, South and West, daily milk volume per producer averaged larger for the bulk shippers than for the can shippers delivering to the same firms in both years 1953 and 1955 (fig. 5).

Although number of bulk shippers increased from 1953 to 1955, there were fewer farms shipping milk in bulk than in cans in the latter year. But milk volume shipped daily averaged much larger for bulk than for can shippers. Between 1953 and 1955, both the number of can shippers and their size of daily shipment decreased in every Region. To the extent that actual costs rather than the less-readily calculated advantages and conveniences to farmers are the real factors determining a shift to bulk assembly, the amount and pattern of the changes in cost encourage the larger-volume group of the remaining can producers to be the next group to install bulk tanks. Thus over time, the producers who are confronted with the question of installing bulk tanks are progressively smaller and smaller-volume shippers.

The decision whether to shift to bulk involves one of two sorts of consequences. To stay with cans may mean loss of market outlet or increased hauling cost, but to shift to

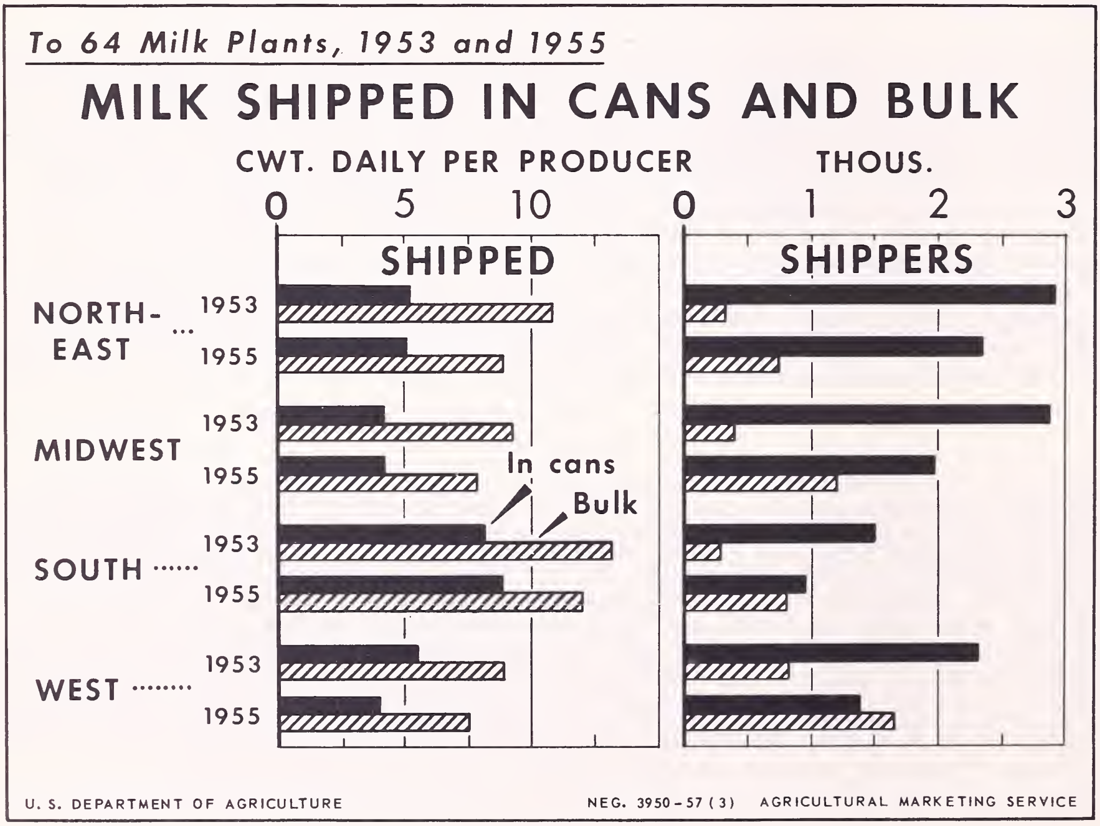

Figure 5

bulk tanks may mean increased farm cooling cost. Among the impacts on dairy farmers of the shift to bulk milk assembly, farm-to-plant, are: (1) producers are encouraged to increase milk volume per farm and (2) smaller producers are encouraged to shift out of fluid milk production or out of dairying, because their costs are raised and their returns lowered.

In the Chicago milkshed, producers who shifted from can to bulk, increased their average daily shipment of milk 13 percent, those who continued to ship by can, only 5 percent, from 1954-55 to 1955-56. Smaller producers shifting to bulk increased production about 15 percent, compared with 7 percent increase for small producers continuing to ship by can; larger producers shifting to bulk increased production about 10 percent, compared with 1 percent to 4 percent increase for larger producers continuing to ship by can.[12]

Pressure to increase milk volume per farm results from combinations of cost effects. With the shift from can to bulk handling, farm cost of cooling the milk has been shown (page 43) to increase, (1) by larger amounts for smaller than for larger-capacity milk tanks and (2) for each tank capacity, for smaller than for larger levels of milk volume (i. e., for lower than for higher levels of use). Similarly, labor time and cost for collecting the milk, largely a fixed cost per farm stop regardless of milk volume, has been shown (page 29) to increase by larger amounts for smaller than for larger milk volume per collection. One way of reducing the hauler's labor cost per hundredweight of milk picked up (by increasing milk volume per collection stop), is by skip-a-day collection of the milk, a practice offering proportionately larger savings in hauler's labor cost per hundredweight on farms with smaller than with larger daily milk volume (243). Skip-a-day collection of the milk increases fixed cost per hundredweight for the farmer by reducing the level of use of tank capacity. Thus the structure of milk-cooling and milk-hauling cost encourages increased milk production per farm following conversion from can to bulk assembly, and encourages larger proportionate increases for smaller daily milk volumes than for larger.

Both milk volume and numbers of can and bulk shippers change as an area shifts to bulk assembly (fig. 6). In the Puget Sound, Washington, marketing area, milk volume for all shippers increased one-fifth from 1951 to 1956. Milk volume shipped daily decreased for can shippers and increased for bulk shippers in the 5 years studied. Milk volume for all shippers averaged about the same as for can shippers in 1951 and 1952, but shifted much nearer to average for bulk shippers by 1955 and 1956 (upper panels) as numbers of bulk shippers increased and can shippers decreased (lower panels). Average milk volume for bulk shippers increased more rapidly for the low month (right) than for the peak month (left), reducing the seasonality of milk supply. Over the 5 years studied, seasonal variation in milk shipment was unchanged for can shippers at about 50 percent larger for the peak than the low month; but seasonal variation decreased for bulk shippers and for the market as a whole. While milk volume in both May and November was increasing for the average bulk shipper and was decreasing for the average can shipper (upper chart), the number of bulk shippers was increasing rapidly and the number of can producers decreasing (lower chart).

One expectation that has been widely reported is that, as the number of bulk milk shippers increased and the number of can shippers decreased, the average size for bulk shippers would decrease because of the progressively decreasing size of the can shippers converting to bulk systems. In the Puget Sound, Washington, milk marketing area, there was a steady decrease in average volume among can shippers, from a seasonal range of about 400 to 600 pounds in 1951 to about 300 to 500 pounds of milk daily in 1955. Also, contrary to expectation, the average volume for bulk shippers remained substantially unchanged at about 600 to 800 pounds of milk daily. Apparently in each year it was mainly the larger can shippers who converted to bulk handling. This would explain the decrease in average daily milk shipment by can. But it appears also that many of the producers

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[12] Colebank, A. W., Market Administrator, Chicago, Ill., report to Director, Dairy Division, AMS, U. S. Dept. of Agr., Nov. 30, 1956.

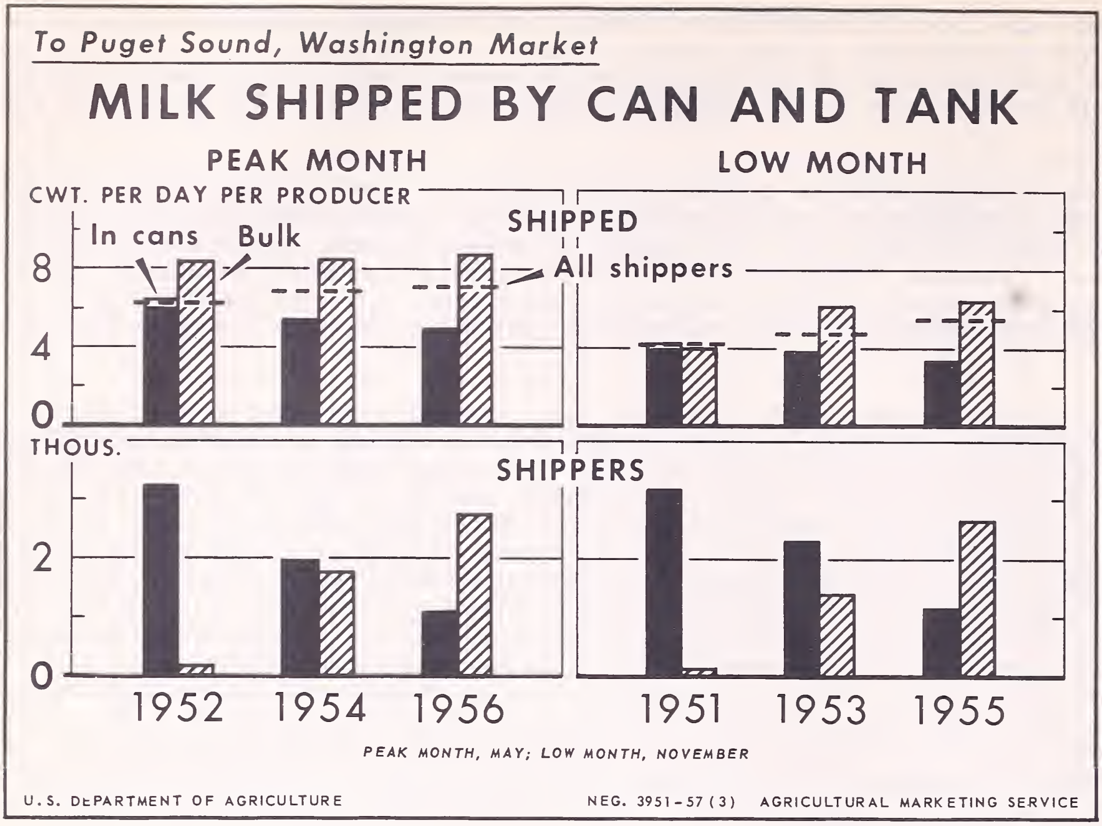

Figure 6

who installed bulk handling systems then increased their milk production. This would help explain the absence of a downward trend in average size of bulk shipments.

Another factor contributing to the rapid decline in the number of can shippers has been the tendency for smaller-scale can shippers to shift away from producing milk for fluid use rather than to incur the expense of installing tanks (38, 90, 96, 216, 334), when faced with area-wide conversion of fluid-milk collection routes and plants to bulk assembly. Reports from each region--Northwest, Midwest, Plains, Lake States, and South--show that some small-volume milk producers who handle milk by can have shifted to selling their milk for manufacturing purposes, and others have sold their herds and quit dairying entirely (38, 90, 96, 216, 268).

The small producer's problem of prospective loss of market outlets or, alternatively, relatively sizable investments, is not confined to the selection of equipment for cooling and handling the milk. Average investment in buildings and facilities for qualifying to ship fluid milk to the Detroit market was reported at $1,200 per farm or nearly $90 per cow for 1953 (178). Describing how Evansville, Ind., promoted a Grade A milk program in 1949, Thom reported investment cost for converting farms to Grade A ranged from $300 to $1,000 per farm, depending on how much of the work the farmer did himself. "Although in 1945 less than 10 producers in the Evansville supply area could have qualified under U. S. Public Health Service requirements, 475 were qualified by 1949 and about 200 others were remodeling their buildings. When the program was first introduced, about 100 marginal producers dropped their dairy enterprise rather than comply with market requirements," he states (304).

In a few cases, producers are reported to have developed specialized dairy enterprises by installing bulk assembly and shifting market outlets from cream sales to manufacturing-milk sales or from manufacturing-milk to fluid milk sales (57, 216, 299).

Producer Problems in Shifting to Bulk Handling

Among the problems of producers shifting to bulk handling are (1) recovering the remaining use-value in old can equipment and (2) financing the increase in investment. Some of the remaining value of old equipment can be salvaged as trade-in value with the purchase of the bulk tank, as long as there is resale demand for the cans and coolers from other producers. Limited reports from widely scattered areas indicate that some farmers who must handle their own sales of can equipment are able to sell as much as three-fourths of their milk cans at prices averaging one-half of purchase price (29, 31). Other farmers are able to make down payments on farm tanks with their old can equipment (233), through arrangements either made by the dealer or by the dairy plant as part of its program to assist producers in financing the installation of bulk equipment.

Only three-fifths of the producers installing bulk equipment in a New England milkshed had a credit problem (271). During 1954, the Connecticut Milk Producers' Association found that two-fifths of its members who were purchasing farm tanks paid cash. Three-fifths arranged for loans with repayment periods distributed about equally into groups of 5 years or less, and 5 years or more. A Hartford, Connecticut, commercial bank was reported as preferring to finance farm tanks for 3 years or less; and figuring that repayment out of savings would take at least 5 years (271).

The farmer's problem of obtaining credit to finance the bulk tank installation is made more difficult by the large amount of investment required for the bulk milk tank, large additional investments on many farms for farm lane improvement, alteration of the milkhouse or rewiring the milkhouse, barn, or farmstead (31, 259, 313), and the uncertainty of additional returns sufficient to amortize the investment.

The usual source of financing purchase of farm equipment, other than a cash purchase, is dealer credit or an equipment loan of short or intermediate term, secured by a chattel mortgage on the tank, obtained from a bank or production credit association. For the larger investments commercial banks are reported to require long-term loans secured by a real estate mortgage including the tank. If a milk company of "substantial" worth is willing to endorse the farmer's paper, some banks may consider intermediate-term financing (271). But in a majority of the reports from scattered localities throughout the U. S. the financing of farm installations of bulk milk tanks by commercial banks is limited to short-term loans of 3 years or less (90, 91, 97, 209, 233), even where the financing is arranged through the producers' cooperative.

Many milk producers' cooperatives throughout the principal dairy areas in the Northeast, Midwest, Lake States, and Northwest have developed programs of financing producer installations (31, 35, 90, 91, 97, 209, 233). Provisions range from the simple to the complex. A simple arrangement is for the association to discount the producers' notes at the bank and check off the repayments from the producers' monthly milk checks. In a complex arrangement, the association purchases the tanks in quantity lots for resale at less-than-retail prices to their farmer-members. It disposes of the producers' old can equipment, installs, calibrates and services the tanks, arranges financing and checks off intermediate-to-long-term repayments from producers' monthly milk checks (9, 33, 35, 97).

Commercial milk plants as well as producers' cooperative associations have arranged financial assistance for producers willing to convert to bulk. In a 1953 survey, about half reported providing some direct financial assistance to their producers, and nearly half reported purchase of farm tanks for resale to their producers. About two-thirds of the Northwestern milk plants, but less than half of the Northeastern, reported such financial assistance (294). Other Northeastern plants are reported (80, 215, 270) to retain ownership of the farm tanks and check off a moderate monthly rental from the producers' milk checks; however, only about one plant in ten in the Northeast reported retaining ownership of tanks on farms.

Hauling-Cost Reductions and Milk-Price Premiums to Producers From Milk-Plant Savings

Milk plants use other incentives to encourage farmers to install bulk equipment. Absorbing a portion of the milk assembly cost, either directly where the tank truck is owned by the plant, or through payment of a subsidy to the truck route owner (page 35), and paying price premiums for milk cooled and handled in bulk, are examples. The practice of partially absorbing hauling cost is common with can assembly in many areas. The payment of premiums would, of course, represent a sharing of the plant's cost savings between the plant and the farmers who supply its milk.

The large saving in investments and costs is the main advantage in converting milk plants to bulk receiving (page 14, 16). For plant to convert to bulk its milk producers must also, and most producers have small enough milk volumes that their own investments and costs will increase substantially as they convert their farm equipment from can to bulk systems. Further, the amount of change in farm cooling cost represents an increase of fixed amount and indefinite duration. Although the economies in route cost may be long-lasting, changes in rates may be only temporary. Any offsets to farm costs in the form of reduced hauling rates are by their nature temporary in both amount and duration, more so where the plant absorbs part of the hauling cost than where there is a reduction in real costs. In this unstable situation, milk plant operators have in some cases encouraged their producers to convert by using subsidy payments to haulers or price premiums to producers. The payment by milk plants of subsidies to milk haulers is, of course, not new (page 35) (74, 78, 302). The payment of price premiums to farmers for bulk milk was reported by nearly half of the milk plants surveyed in each region, Northeast, Midwest and Northwest, in 1953 (294). In a later survey, the proportion of plants paying premiums for bulk milk ranged from three-fifths, in the Northeast and Midwest, to one-fourth in the West and only 1 percent in the South; again about half of all plants throughout the U. S. reported premiums (80).

Stocker speculated on the cycle of premium payments in 1953: "The level may be voluntarily established by the pioneer firm, or gained by the producers' bargaining association on a marketwide basis. Eventually when conversion to bulk tanks reaches a certain level the premiums may be reduced or disappear entirely." (294) Cowden reported in 1956: "Several firms indicated that premiums paid at the time of the survey in 1955 were temporary in nature and might be discontinued at any time. In some cases premiums were guaranteed for specified period or until the producer's tank is paid for." (80). The temporary nature of "voluntary" premiums has stimulated producers' cooperatives to seek administrative and legislative authority in State or Federal-State milk control laws and regulations for bulk milk premiums as a part of the milk price structure.

In a survey of producers' cooperatives in the main metropolitan areas where milk marketing is regulated by State or Federal order, Johnson (176) found three-fifths of the markets reported some dairy plants and farms equipped for bulk handling; more than half of these reported that premiums were being paid for bulk milk, in the range from 2.5 cents to 25 cents per hundredweight. From most markets the premium for bulk milk was 5 cents, 10 cents, or 15 cents per hundredweight.

Premiums paid to producers supplying bulk milk are most often in addition to reductions in hauling rates. For example, in one market the producers' cooperative reported that producers were receiving a premium of only 8 cents, although on the average bulk shippers received 17 cents more net benefits per hundredweight than can shippers (176). Presumably, hauling rates for bulk milk were 9 cents per hundredweight less than for milk in cans. Stocker (294) found that premium payments for bulk-hauled milk were in most cases additional to reduced hauling charges. Changes in net return to producers were found in four main patterns: (1) Premium payment only, in a small number of cases, (2) reduced hauling charge only, (3) large premium combined with smaller reduction in hauling charge, (4) small or no premium combined with larger reduction in hauling charge (table 24).

TABLE 24.--AMOUNT OF HAULING-COST REDUCTIONS OR MILK-PRICE PREMIUMS TO FARMERS DELIVERING MILK BY BULK

Area	Number of plants reporting	Average premium payment	Average reduction in hauling charge	Average total share to producer of savings in plant and hauling cost
For plants reporting price premiums of 10 cents per hundredweight or more				
	Number	*Cents*	*Cents*	*Cents*
Northeast............	5	10.5	7.6	18.1
Midwest..............	11	12.7	1.0	13.7
Northwest............	13	13.2	2.2	15.4
Total or Average.....	29	12.5	2.7	15.2
For plants reporting price premiums of 9 cents or less				
Northeast............	17	1.8	7.5	9.3
Midwest..............	17	1.8	6.0	7.8
Northwest............	8	1.0	10.6	11.6
Total or Average.....	[1] 42	1.7	8.6	10.3

[1] Including 31 plants reporting no premium payment, distributed 11 for the Northeast, 13 for the Midwest, 7 for the Northwest.

Compiled from data published by Farmer Cooperative Service.

For plants reporting bulk premiums of 9 cents or less per hundredweight, the increase in producers' net return for bulk milk averaged 10.3 cents; for plants reporting premiums of 10 cents or more, the increase in producers' net return averaged 15.2 cents. For 42 plants in the group reporting low-premium payments, the amount by which hauling charges was reduced averaged 8.6 cents per hundredweight and the premium 1.7 cents per hundredweight. For the 29 plants in the group reporting high-premium payments, the amount of reduction in hauling charge averaged much less, only 2.7 cents per hundredweight, and the premium much more, 12.5 cents per hundredweight.

The payment of price premiums for bulk milk to farmers (or hauling-cost subsidies to haulers for keeping charges below costs) do not necessarily represent net gains to farmers. There may be offsetting increases in costs of two kinds: Those directly related to the type and size of the equipment and the volume of milk cooled, as discussed above, or those related to functions that are shifted because of the change from cans to bulk (p. 45). Most of the receiving operation, a combination of tasks that with milk in cans was done at the plant receiving-room or country receiving station, is shifted with bulk handling to the farm, and its tasks to the truck driver and the farmer.

CHANGES IN MILK ASSEMBLY COST AND SOME IMPLICATIONS

Tank assembly of milk extends bulk handling techniques that, because of labor-saving and cost-reducing advantages, were adopted earlier in city milk plants and country assembly plants. Tank assembly is part of a larger trend toward marketing a wide range of farm products in bulk, but it is unlikely to eliminate all can assembly in the foreseeable future. Industry sources and researchers express widely differing opinions with

respect to the rate of further extension of bulk assembly and the extent of can assembly when the adoption of bulk facilities has finally reached saturation.[13]

Potential savings in farm-to-plant milk assembly cost attributable to the introduction of bulk cooling and handling on the farm and milk collection route, as well as at plants, are estimated at about $5 million to $12.5 million per year for the large metropolitan centers and markets where milk marketing is regulated by Federal or State authority.[14] The milk marketed by farmers in these markets is estimated to represent about one-half the total milk volume sold by farmers. Large additional quantities of milk are subject to the same potential savings in the unregulated markets, and in the assembly of milk for manufacturing purposes.

There may be little direct saving in the cost of assembling milk for an entire market in some areas; there are certain to be substantial savings in others. Throughout a producing area and its market, fixed costs of milk assembly will increase as existing equipment--on the farm, on the route and in the plant--is replaced with new, bulk or can.[15] The trend to bulk is likely to depend mostly on the large savings in investments and costs for most milk plants. The substantial increases in costs on many farms shifted to bulk are less likely to limit the spread of bulk assembly than to alter traditional market practices.

The farmer will be able to offset part of the cost increases with savings in the form of reduced milk loss, part in some saving in the amount and difficulty of his chore work, and most farmers can, initially at least, obtain some reduction in hauling rates. But, in most cases, the farmer has to have a premium for his milk to make a switch to bulk handling pay. Such premiums depend, of course, on savings in milk assembly cost; the savings in turn depend in part on the extent of installation of bulk equipment on farms, at milk plants, and on milk collection routes, and in part on reorganization to increase efficiency.

The extent of bulk equipment installation is affected by producer size, market outlet, the price he receives for milk, and to some extent by the decisions made by neighboring farmers whether to shift to bulk. The ultimate extent of bulk assembly is likely to be at some point short of its complete adoption by all the farms currently selling whole milk and all plants receiving whole milk; some will discontinue milk operations rather than convert. Dairy farming, like milk marketing, will continue to become larger-scale and more specialized, and bulk assembly will become an additional factor in the trend. Bulk equipment will be installed on a larger proportion of the total plants and farms under fluid-milk operations than under manufacturing operations, in part because of differences in milk volume and operating cost (128, 144, 181, 239, 240, 266, 288, 309, 314), and in part because of differences in prices to producers.

The higher producer price for fluid milk, and the larger-scale production typical of fluid milk producers, compared with manufacturing milk producers, offers better prospects for financing the equipment investment in bulk coolers than the lower producer price or the smaller-scale production of manufacturing milk.

In some markets, especially unregulated markets or those with individual-handler pools, those handlers with largest fluid milk (Class I) utilization will be likely eventually to draw all or nearly all of their milk supplies from farms with bulk milk tanks.[16] Significant numbers of milk plants are already converted to 100 percent bulk receiving. The

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[13] See, for example, reference nos. 14, 15, 17, 39, 48-54, 60, 62, 64, 83, 84, 93, 119, 120, 122, 123, 125, 134, 136, 138, 139, 141, 154, 155, 165, 167, 182, 184, 188, 191, 199, 225, 226, 229, 230-232, 244, 248, 260, 265, 267, 275, 276, 281, 285, 287, 290, 292, 293, 305, 306, 329, 338, 339, 341, 342.

[14] This estimate is based on estimated net savings of 2 cents to 5 cents per hundredweight of milk for fluid uses alone, amounting to 18 billion pounds for the 67 Federal order markets and 10 billion pounds for the markets controlled under State law in 16 States (127).

[15] Initially, investing in bulk handling equipment would amount to replacing old equipment bought at lower, prewar price levels with new equipment bought at higher, postwar price levels. However, the cost of all new can equipment generally would be larger than for bulk equipment of the same capacity.

[16] According to Cowan, all the dairy plants within the city limits of Seattle were receiving only milk from farm tanks in 1956 (56).

number of plants receiving milk by can is declining because many small milk receiving and cooling plants presently equipped for can-receiving only are being closed rather than converted.

The major trends of the past five years appear likely to continue: (1) moderate to rapid increase in the number of milk plants, milk routes and farms shifted from can to bulk equipment; and (2) rapid spread of bulk handling in some localities or producing areas and slow change or none in others.

In areas where conditions are ripe for bulk handling of milk, farm-to-plant, the increased farm cost will force some small-scale farmers to withdraw from the market or to greatly increase milk production. Some of the adjustments may be painful (207, 303, 328, 344). The prospect of loss of a fluid milk outlet or greatly increased hauling cost for producers who continue to handle milk in cans when other producers are installing bulk milk tanks may be as potent a factor in the spread of bulk handling on farms as savings in direct costs. (121, 212).

The total reduction in the net cost of assembling milk to market will depend only in part on the extent to which bulk handling replaces can. Such a technological change offers opportunities for sweeping reorganization to eliminate inefficiencies that have gradually developed over many years or crept into business systems or practices. Can-assembly routes and milk-receiving operations could have been reorganized for greater efficiency and lower-cost operation, even if bulk assembly had not come along. Such changes will undoubtedly continue to be made in can-assembly systems in addition to savings brought about by, or made concurrently with, the adoption of bulk assembly.

The full potential saving obtainable as a result of the introduction of bulk milk assembly thus includes: The net amount of saving in assembly cost under mixed (or part-bulk and part-can) systems when the shift to bulk has reached equilibrium, the net saving from reorganization of remaining can-assembly routes and can-receiving operations, and the net saving from increased scale of production at the larger-sized individual dairy plants and individual dairy farms.

The amount of potential saving from each source, and especially from continuing reorganization to improve productivity, appears to be substantial.

APPENDIX TABLES

TABLE 25.--INVESTMENT IN EQUIPMENT FOR RECEIVING AND COOLING MILK BY CAN AND BULK AT VARYING CAPACITIES

Equipment item	Capacities of 200-599 hundredweight				
	Can receiving				Bulk receiving
	Minnesota 1946 (280 cwts.)	Washington 1952 (280 cwts.)	Northeast 1951 (300 cwts.)	Northwest 1946 (376 cwts.)	Washington 1952 (200-301 cwts.)
Equipment that would be eliminated by all-bulk receiving:					
Conveyors	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
In	---	(347)	---	---	---
Out	---	(200)	---	---	---
Platform	---	---	---	---	---
Reject slide	---	---	---	---	---
Total		547	3,315	---	---
Dumping equipment	---	37	) 3,237	---	---
Weigh can, scale	---	3,333	)	---	---
Can washer[1]	---	1,748	1,843	---	---
Subtotal	---	5,665	8,395	---	---
Other receiving equipment:					
Pump	74	484	)	---	524
Clarifier	442	4,335	) 907	---	5,373
Sampling, recording	175	50	)	---	---
Sanitary pipe, fittings	421	169	)	---	579
Coldwall storage tank	3,403	3,710	7,536	---	7,920
Plate cooler	---	---	3,118	---	---
Subtotal	[2] 5,215	8,748	11,561	---	14,396
Total receiving equipment	---	14,412	19,956	[3] 10,195	14,396

See footnotes at end of table.

(Continued)

TABLE 25.--INVESTMENT IN EQUIPMENT FOR RECEIVING AND COOLING MILK BY CAN AND BULK AT VARYING CAPACITIES--Continued

Equipment item	Capacities of 600-899 hundredweight			
	Can receiving			Bulk receiving
	Northwest 1946 (563 cwts.)	Washington 1952 (700 cwts.)	Northwest 1946 (752-938 cwts.)	Washington 1952 (600-860 cwts.)
Equipment that would be eliminated by all-bulk receiving:				
Conveyors	*Dollars*	*Dollars*	*Dollars*	*Dollars*
In	---	(1,844)	---	---
Out	---	(577)	---	---
Platform	---	---	---	---
Reject slide	---	---	---	---
Total	---	2,421	---	---
Dumping equipment	---	136	---	---
Weigh can, scale	---	3,528	---	---
Can washer[1]	---	3,870	---	---
Subtotal	---	9,955	---	---
Other receiving equipment:				
Pump	---	594	---	1,284
Clarifier	---	5,700	---	5,730
Sampling, recording		1,506	---	---
Sanitary pipe, fittings	---	770	---	1,483
Coldwall storage tank	---	10,780	---	15,220
Plate cooler	---	---	---	4,350
Subtotal	---	19,350	---	28,067
Total receiving equipment	[3] 10,195	29,417	[3] 11,180-11,905	28,067

See footnotes at end of table.

(Continued)

TABLE 25.--INVESTMENT IN EQUIPMENT FOR RECEIVING AND COOLING MILK BY CAN AND BULK AT VARYING CAPACITIES--Continued

Equipment item	Capacities of 1,100-1,600 hundredweight			
	Can receiving		Bulk receiving	
	Washington 1952 (1100 cwts.)	Northwest 1946 (1253-2004 cwts.)	Washington 1952 (1155-1540 cwts.)	Illinois 1946 (1056 cwts.)
Equipment that would be eliminated by all-bulk receiving:				
Conveyors	*Dollars*	*Dollars*	*Dollars*	*Dollars*
In	(2,066)	---	---	---
Out	(2,184)	---	---	---
Platform	(55)	---	---	---
Reject slide	(103)	---	---	---
Total	4,408	---	---	---
Dumping equipment	402	---	---	---
Weigh can, scale	5,596	---	---	---
Can washer[1]	4,200	---	---	---
Subtotal	14,610	---	---	---
Other receiving equipment:				
Pump	866	---	1,632	163
Clarifier	5,700	---	5,730	[4] 4,984
Sampling, recording	1,950	---	---	---
Sanitary pipe, fittings	659	---	2,731	764
Coldwall storage tank	13,680	---	23,800	[5] 8,001
Plate cooler	3,170	---	4,350	---
Subtotal	26,025	---	38,243	[6] 13,911
Total receiving equipment	40,630	[3] 22,905-27,785	38,243	---

[1] A firm that receives all milk in bulk (by tank truck) and sells some of its milk products in "bulk" (in 10 gallon spigot cans, mainly to restaurants and institutions) or cream in cans, would nevertheless need a can-washer although its capacity and cost would be much less than indicated by volume received. [2] Plus refrigeration equipment amounting to $5,215. [3] Plus refrigeration equipment amounting to $8,950 at 376 cwts. daily, $10,400 at 563 cwts. daily, $11,075 to $12,875 at 752 and 938 cwts. respectively, and $14,100 to $16,200 at 1,253 and 2,004 cwts. respectively. [4] Two clarifiers. [5] Three receiving tanks. [6] Plus refrigeration equipment amounting to $5,420.

TABLE 26.--COST PER HUNDREDWEIGHT OF RECEIVING AND COOLING MILK BY BULK AND BY CAN AT DAIRY PLANTS

Daily milk volume (Hundred-weight)	Cost element	By bulk				By can						
						Northwest			Midwest			
		Washington 1953[1]	Illinois 1946	Wisconsin 1952	Northeast 1956	Washington 1953[1]	Washington-Oregon-Idaho 1948		Minnesota 1946[3]	Wisconsin 1951[4]	Northeast 1950[5]	Southeast 1952[6]
							Observed plants[2]	Model plants[2]				
		Cents	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*
Under 100..												(55-96 cwts.)
	Fixed											---
	Variable	---	---	---	---	---	---	---	---	---	---	---
	Total											21.4-10.2
100-199....					(143 cwts.)	(120 cwts.)						(101-189 cwts.)
	Fixed				2.0	12.9						---
	Variable	---	---	---	1.6	38.8	---	---	---	---		---
	Total				3.3	51.8						16.3-5.9
200-399....		(200-301 cwts.)				(280 cwts.)	(260-319 cwts.)		(260 cwts.)		(318 cwts.)	(274-288 cwts.)
	Fixed	3.8				10.6	0.4-2.3		1.8		7.2	---
	Variable	7.5	---	---	---	31.6	2.5-3.3	---	7.2	---	3.6	---
	Total	11.3				42.2	2.9-5.6		9.0		10.8	12.4-26.8
400-599.....				(400 cwts.)		(420 cwts.)		(476-572 cwts.)		(400 cwts.)		
	Fixed			0.9		9.8		---		6.1		
	Variable	---	---	2.2	---	29.2	---	---	---	19.0	---	---
	Total			3.1		38.9		1.5-3.1		25.1		
600-799....		(600-800 cwts.)		(750 cwts.)		(705 cwts.)	(614 cwts.)	(714 cwts.)		(750 cwts.)		
	Fixed	3.2		0.5		8.4	0.9	---		4.6		
	Variable	6.2	---	2.0		25.0	1.6	---		13.2	---	---
	Total	9.4		2.5		33.4	2.5	1.2-2.1		17.8		
800-1,099...		(800-860 cwts.)	(1,020 cwts.)			(1,140 cwts.)	(817-1,055 cwts.)	(952-1,888 cwts.)				
	Fixed	3.2	1.3			6.6	1.0-2.4	---				
	Variable	6.2	3.6	---	---	19.6	2.8-4.5	---	---	---	---	---
	Total	9.4	4.9			26.2	3.8-6.9	0.9-1.7				
1,200-1,599.		(1,200-1,540 cwts.)		(1,600 cwts.)			(1,421-1,560 cwts.)	(1,587 cwts.)		(1,600 cwts.)		
	Fixed	2.8		0.3			1.0-1.1	---		2.0		
	Variable	5.6	---	2.0	---	---	3.0-3.3	---	---	7.4	---	---
	Total	8.4		2.3			4.0-4.4	1.3		9.4		

[1] (Washington) Fixed and variable costs per hundredweight: Fixed including depreciation, insurance, audit and legal, managerial, interest and taxes; variable including labor, steam, power and light, supplies, laboratory, repairs, bank charges, general expenses, telephone and telegraph, and miscellaneous. Ranges in volume for bulk plants represents optimum and maximum volume.

[2] (Idaho) Fixed and variable cost represent capital and labor cost only, data converted from 1,000 pound to hundredweight basis. Excludes receiving-cost share of office expenses, overhead cost, boiler expense, electricity, water, factory supply, and management, which were not allocated to functions. Cooling costs excluded (not reported separately by plant size) but, combined with waste disposal, fire protection and plant security, average 1.1 cents per hundredweight; model plant costs from ((320), table 54).

[3] (Illinois-Minnesota) Costs per hundredweight calculated by summing receiving and refrigeration cost data and converting 1,000 gallons into hundredweights. Fixed and variable costs apportioned, fixed including general expense, space, equipment, and variable including labor, electric power and light, steam, building heat, administration, office, repairs and maintenance. Data represent two plants.

[4] (Wisconsin) Fixed and variable costs: Fixed including depreciation, insurance, taxes, repair and maintenance; variable including labor, fuel and power, supplies, water and sewage. Data represent range of four plants.

[5] (Northeast) Costs per hundredweight calculated from published cost data divided by 318 hundredweights daily volume.

[6] (Southeast) Total cost only; data represent 16 plants in Georgia, Mississippi, South Carolina, and Tennessee.

Sources: Compiled from reports of the Washington, Idaho, Illinois, Wisconsin, New York, Virginia, and Georgia Agricultural Experiment Stations.

TABLE 27.--DAILY MILK-COOLING REQUIREMENT AND POWER COST FOR CAN AND BULK MILK-RECEIVING ROOMS AT VARYING CAPACITY AND MILK VOLUME, WESTERN WASHINGTON[1]

Item	Unit	Requirement for plants with capacity for daily milk volume: 100-199	200-399	400-599	600-799	800-1199	1200-1599
Can-receiving							
		(120 cwt.)	(280 cwt)	(420 cwt)	(705 cwt)	(1140 cwt)	
Refrigeration.	Tons	---	2.007-1.059	3.010-1.850	5.125-3.005	8.214-5.054	---
Compressor....	Horsepower	---	2.585-1.327	4.750-2.310	6.400-3.750	10.250-6.330	---
Power.........	KWH	---	2.270-1.160	3.840-2.120	5.625-3.290	9.550-4.440	---
Power cost....	Cents	2.29-2.94	1.87-3.13	1.72-3.01	1.48-2.14	1.16-1.56	---
Bulk-receiving							
			[2] (200-301 cwt.)		[2](600-860 cwt.)		[2](1155-1540 cwt.)
Refrigeration.	Tons	---	1.217-0.684	---	3.638-2.148	---	6.034-3.474
Compressor....	Horsepower	---	1.520-0.855	---	4.540-2.690	---	7.545-4.320
Power.........	KWH	---	1.330-0.751	---	3.980-2.360	---	6.620-3.790
Power cost....	Cents	---	0.75-0.90	---	0.60-0.76	---	0.54-0.70

[1] Paired figures represent daily milk volume equivalent to 100% and 50% of plant capacity, respectively.
[2] Ranges represent optimum and maximum capacity of plants as defined in reference source.

Source: Compiled from reports of Washington Agricultural Experiment Station.

TABLE 28.--COSTS FOR UTILITIES AND FACTORY SUPPLIES FOR CAN AND BULK MILK-RECEIVING OPERATIONS AT VARIOUS PLANT CAPACITIES AND MILK VOLUMES[1]

Plant capacity in daily milk volume (Cwt.)	Receiving cost per hundredweight for utilities and factory supplies for plants receiving milk by:						
	Bulk			Can			
	Electric power and light	Steam	Factory supplies	Electric power and light	Steam	Total utilities	Factory supplies
	Cents	Cents	Cents	Cents	Cents	Cents	Cents
100-199				(120 cwt.) 2.3 2.9	(120 cwt.) 8.3 10.9		(120 cwt.) 2.1 3.5
200-399	(310 cwt.) 0.75 0.90	(310 cwt.) 0.24 0.28	(310 cwt.) 0.48 .75	[2] (280 cwt.) 1.9 ---	(280 cwt.) 6.8 9.2	[3] (320 cwt.) 2.9 ---	(280 cwt.) 1.7 2.8 [3] (320 cwt.) 0.8 ---
400-599	(400 cwt.) [4] .35 ---	(400 cwt.) [4] .22 ---	(400 cwt.) [4] .22 ---	(420 cwt.) 1.7 3.0	(420 cwt.) 6.2 9.1		(420 cwt.) 1.6 3.1
600-799	(750 cwt.) [4] .40 ---	(750 cwt.) [4] .23 ---	(750 cwt.) [4] .22 ---	(705 cwt.) 1.4 2.1	(705 cwt.) 5.4 7.3		(705 cwt.) 1.4 1.8
800-1199	(860 cwt.) 0.60 0.76 [5] (1060 cwt.) 0.06 ---	(860 cwt.) 0.19 0.25 [5] (1060 cwt.) 0.10 ---	(860 cwt.) 0.40 0.54 --- --- ---	(1140 cwt.) 1.2 1.6	(1140 cwt.) 4.2 5.7		(1140 cwt.) 1.1 1.4
1200-1599	(1540 cwt.) 0.54 .70	(1540 cwt.) 0.18 .21	(1540 cwt.) 0.35 .44				

[1] Upper figure in each pair represents milk volume equivalent to full capacity; lower figure volume equivalent to one-half capacity. Data for Western Washington except where otherwise noted. [2] Data for Minnesota. [3] Data for Northeast. [4] Data for Wisconsin. [5] Data for Illinois.

Compiled from reports of Washington, Virginia, Illinois and Wisconsin agricultural experiment stations.

TABLE 29.--LABOR REQUIREMENTS FOR CAN AND BULK MILK-RECEIVING OPERATIONS FOR VARIOUS PLANT CAPACITIES, AND MILK VOLUMES[1]

Plant capacity in daily milk volume (cwt.)	Labor requirement per hundredweight of milk for receiving milk by:									
	Bulk		Can							
			Northwest		Midwest			Northeast		Southeast
					Indiana 1952[2] [4]					
	Washington 1953[2]	Illinois 1946[2]	Washington 1953[2]	Washington Oregon Idaho 1948[3]	Manu-facturing plants	Fluid plants	Minnesota 1946[2]	New York 1953[3]	Northeast 1953[2]	1948[2]
	Minutes	*Minutes*	*Minutes*	*Minutes*	*Minutes*	*Minutes*	*Minutes*	*Minutes*	*Minutes*	*Minutes*
0-199			(120 cwt.) 3.70 4.42			(100-110 cwt.) 1.9-2.3 ---		(70-80 cwt.) 4.1-2.0 ---		(55-290 cwt.) 4.8-0.6 ---
200-399	(301 cwt.) .96 .91		(280 cwt.) 3.02 3.42		(230 cwt.) 1.5 ---	(270-350 cwt.) 1.8-0.9 ---	(280 cwt.) 1.5 ---		(320 cwt.) .55 1.21	(55-290 cwt.) 4.8-0.6 ---
400-599			(420 cwt.) 2.77 3.28	(480-570 cwt.) 1.32-1.10 ---	(480-570 cwt.) 1.9-3.3 ---					
600-799			(705 cwt.) 2.38 3.12	(710 cwt.) .88 ---	(720-780 cwt.) 1.5-2.2 ---	(625 cwt.) 0.7 ---				
800-1,199	(860 cwt.) .75 .76	(1,060 cwt.) 0.6 ---	(1,140 cwt.) 1.87 2.51	(960-1,190 cwt.) .66-.53 ---	(885-1,160 cwt.) 1.4-1.5 ---					
1,200-1,599	(1,540 cwt.) .69 .74			(1,590 cwt.) .54 ---	(1,250-1,550 cwt.) 1.3-1.7 ---	(1,240 cwt.) 1.4 ---				

1 Where paired, upper figure represents requirement at volume approximately equal to full capacity; lower figure, at volume equal to one-half capacity.
2 Calculated by dividing total daily labor requirement for receiving by daily volume, from data in reference source.
3 Compiled from data presented in reference source.
4 Clean-up time excluded.

Compiled from reports of Washington, Idaho, Illinois, Indiana, New York, Virginia and Georgia Agricultural Experiment Stations.

TABLE 30.--INVESTMENT IN TRUCKS AND EQUIPMENT FOR HAULING MILK BY BULK TANK

Item	Capacity	Investment as reported for: Calif. 1947	Wash. 1952	Wis. 1952	N. H. 1953	Tenn.-Iowa 1954	Minn.-Wis. 1954
		Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
Small tankers							
Tank	500-1400 gal.			4000-4360	3350-4875		
Chassis	1.0-2.0 ton			---	2250-2700		
Total				---	7900-9875		
Medium tankers							
Tank	1500-1800 gal.		3840	4740	5000	5500-6500	5300-6000
Chassis	2.0-2.5 ton		2730	---	5825	3960	3000-4300
Total			6570	5427	[1] 13125	10250	8300-10000
Large tankers							
Tank	2000-2500 gal.				7000		
Chassis	3.0 ton				8000		
Total					[1] 17300		
Small semi-trailer tankers							
Tank, semi	2000-2500 gal.	4700-5800					
Tractor	Light duty	2000					
Total		7800					
Large semi-trailer tankers							
Tank, semi	3500-3800 gal	6900					
Tractor	Heavy duty[2]	5760					
Total		12660-18440					

[1] Including $1150 for pump compartment, pump and hose.
[2] Tractor, 2 tank trailers of 2000-2500 gallons' capacity, plus $1480 for converter gear.

Compiled from industry reports and published reports of the California, Washington, Wisconsin, New Hampshire, and Indiana agricultural experiment stations.

TABLE 31.--INVESTMENT IN TRUCK AND CONTAINERS FOR HAULING MILK BY CAN

Item	Capacity	Average investment as reported for: Calif. 1947	Wis. 1952	N. H. 1953	Minn.-Wis. 1954	Ind. 1949
		Dollars	Dollars	Dollars	Dollars	Dollars
Small can trucks						
Van	33-66 cans		588.50			
Total			[1] 594.00			
Medium can trucks						
Van	80-150 cans			1000	770-830	[2] 531
Chassis	2.0-2.5 ton			4000	2600-2965	[2] 2197
Total				5000	3430-3735	[2] 2728
Large can trucks						
Total		2500				
Small semi-trailer can trucks						
Van, semi	Rack	1000				
Tractor	Light duty	2000				
Total		3000				
Large semi-trailer or trailer trucks						
Van, semi	250 cans	3990				
Tractor	Heavy duty	5760				
Van, trailer	150 cans	---				
Total		[3] 9750-11870				

[1] Sixty-six 10-gallon cans.
[2] Average reported for 82 of 97 trucks, three-fourths of them less than 2 years old.
[3] Tractor and semi-trailer van, compared with tractor, semi-trailer van, and trailer van.

Compiled from industry reports and published reports of the California, Wisconsin, New Hampshire, Minnesota, and Indiana agricultural experiment stations.

TABLE 32.--FIXED COSTS OF MILK HAULING EQUIPMENT FOR CAN AND BULK MILK ASSEMBLY ROUTES, BY SIZE, AREA AND YEAR

Truck size[1]	Cost element	Range in fixed cost per day as reported for:							
		Tank trucks			Can trucks				
		California 1947	Washington 1952	New Hampshire 1954	California 1947	Washington 1952	New Hampshire 1954	Indiana 1949	North Carolina 1949
		Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Small trucks	Depreciation			2.73					0.87-1.03
	Interest			3.46					.17-.21
	Insurance			---					.30-.31
	Taxes			)---					) .03
	Licenses			)---					)
	Garage			---					.12-.33
	Total			---					1.49-1.90
Medium trucks	Depreciation		1.64	4.96	1.37	1.22	2.51	2.01	1.22-1.45
	Interest		.42	---	.24	.27	---	.20	.24-.34
	Insurance		.20	2.00	.50	.16	1.00	.33	.33-.37
	Taxes		).51	)---	).13	).36	)---	)---	).03-.04
	Licenses		)	)	)	)	)	)	)
	Garage		---	.75	.82	---	.75	---	.33-.50
	Total truck		2.77	7.71	3.06	2.01	4.26	2.54	2.28-2.71
	Driver's wage		---	10.50	---	---	8.75		
Large trucks	Depreciation			6.65					
	Interest			---					
	Insurance			---					
	Taxes			---					
	Licenses			---					
	Garage			---					
	Total			---					
Small semi-trailer trucks	Depreciation	3.99			3.78				
	Interest	.99			.92				
	Insurance	.88			.85				
	Taxes	).55			).64				
	Licenses	)			)				
	Garage	1.15			1.15				
	Total	7.56			7.33				
Large semi-trailer trucks	Depreciation	5.68							
	Interest	1.48							
	Insurance	1.11							
	Taxes	).83							
	Licenses	)							
	Garage	1.15							
	Total	10.25							

[1] Loads corresponding to truck size classification include: for tank trucks, small 500 to 1,450 gal.; medium, 1,500 to 1,950 gal.; large, 2,000 to 2,850 gal.; small semi-trailer, 3,500 gal.; large semi-trailer, 4,500 gal.; for can trucks, small 33 to 75 cans; medium, 80 to 150 cans; small semi-trailer, 250 cans; large semi-trailer, 250 cans plus 150-can trailer.

Compiled from reports of California, Washington, New Hampshire, Indiana, and North Carolina agricultural experiment stations.

TABLE 33.--VARIABLE COSTS OF MILK HAULING EQUIPMENT FOR CAN AND BULK MILK ASSEMBLY ROUTES, BY SIZE, AREA AND YEAR

Truck size[1]	Cost element	Variable cost per mile as reported for:							
		Tank trucks			Can trucks				
		Calif. 1947	Wash. 1952	N. H. 1954	Calif. 1947	Wash. 1952	N. H. 1954	Ind. 1949	N. C. 1949
		Cents	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*
Small trucks	Gasoline.......								1.9-2.3
	Oil............								0.3
	Tires and tubes								1.0-1.5
	Repairs and maintenance..								2.0-2.5
	Total......								5.2-6.6
Medium trucks	Gasoline.......		5.10	5.00	2.21	5.22	5.00	3.39	2.7-2.9
	Oil............								0.3
	Tires and tubes........		1.51	2.76	1.53	1.49	2.30	1.38	1.5
	Repairs and maintenance..		4.08	3.56	7.54	4.29	3.56	1.77	2.5
	Total......		10.69	11.32	11.28	11.00	10.86	6.54	7.0-7.2
Small semi-trailer trucks	Gasoline.......	5.00			5.00				
	Oil............								
	Tires and tubes........	2.72			3.28				
	Repairs and maintenance..	8.50			8.50				
	Total......	16.22			16.78				
Large semi-trailer trucks	Gasoline.......	5.00							
	Oil............								
	Tires and tubes........	3.28							
	Repairs and maintenance..	8.50							
	Total......	16.78							

[1] Loads corresponding to truck size classification include: for tank trucks--small, 500 to 1,450 gal.; medium, 1,500 to 1,950 gal.; large 2,000 to 2,500 gal.; small semi-trailer, 3,500 gal.; large semi-trailer, 4,500 gal.; for can trucks--small, 33 to 75 cans; medium, 80 to 152 cans; small semi-trailer, 250 cans; large semi-trailer, 250 cans plus 150-can trailer.

Compiled from reports of the California, Washington, New Hampshire, Indiana and North Carolina Agr. Expt. Stas.

TABLE 34.--TIME REQUIRED FOR SELECTED SAMPLING AND WEIGHING OPERATIONS IN RECEIVING MILK BY CAN AND BULK

Operation	Time required as reported for:			
	Can operations			Bulk operations
	Indiana	Vermont	Michigan	Michigan
Sampling operations per producer	*Minutes*	*Minutes*	*Minutes*	*Minutes*
Set-up of sampling equipment[1]	---	0.17-0.24	---	0.41
Sampling with:				
Valve....................	)0.094-0.434	0.21	0.07	---
Dipper...................	)	0.28	0.07	0.32
Handling samples...........	---	---	---	0.31
Weighing operations per producer				
Gaging or weighing:				
On farm....................	---	---	---	[2] 0.87
At plant...................	---	---	---	[3] 5.50
Weight recording:				
Manual.....................	)0.034-0.266	0.24	0.13	0.21
Mechanical.................	)	0.14	[4] 0.095	---
Handling weigh slips.........	---	0.13	---	0.85
Dumping time per can............	0.079-0.509	---	---	---
Total time per can for receiving operations.....................	---	0.21-0.43	0.166-0.35	---

[1] Sampling equipment would be set up once daily for can operations, once for each producer for bulk operations.
[2] Operations which must be performed separately from agitation or pumping of the milk.
[3] Including check-gaging at plant.
[4] Cost of print-weigh device at the scales at 1952 prices would be returned by savings in 4.8 years at $1.75 labor cost per hour, for a plant receiving 400 hundredweights daily.

Compiled from reports of the Indiana, Vermont and Michigan agricultural experiment stations.

TABLE 35.--COST OF FARM-TYPE MECHANICAL COOLERS FOR MILK CANS, BY CAPACITY, REGION AND YEAR

Peak daily milk volume[1] in gallons	Cooler capacity	Can cooler cost as reported for:					
		Western Washington[2 3] 1952	Wisconsin[2] 1953	Vermont[2] 1952	New Hampshire[2] 1953	Minnesota[2 3] 1955	Wisconsin[4] 1953
	Cans	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
16	2	---	480	---	---	---	75
29-40	4	418-438	530	---	---	390	105
43-60	6	509	600	504	520	455	135
65-80	8	595	705	580	600	---	180
81-98	10	850	---	---	---	[5] 600	225
100-120	12	---	985	837	875	---	270
120-130	14	666	1,305-1,410	---	---	---	315
146.5	16	---	---	1,160	---	[5] 875	360
160-163	18	776	1,555	---	---	---	---
172	22	---	---	---	---	1,250	---
240	24	886	---	1,674	---	---	---

[1] In the Wisconsin and Minnesota studies, costs were arranged in increments of average milk volume; in the rest, costs were arranged in increments of milk cans (10 gals.).
[2] Mechanically refrigerated.
[3] Plus per-can investment of \$22.20 for Washington, \$33.65 for Minnesota.
[4] "Wet box" or immersion cooler.
[5] Cans about 7-8-gallon capacity in Minnesota study; in other studies, 10 gallons.

Compiled from reports of Agricultural Experiment Stations.

TABLE 36.--COST OF FARM BULK MILK COOLING TANKS, BY CAPACITY, REGION, AND YEAR

Tank capacity (gallons)	Calif. 1947[1]	Pacific Northwest: Western Wash. 1952[1]	Pacific Northwest: Oregon 1953[1]	Pacific Northwest: Idaho 1955[2]	Midwest: Chicago milkshed (Wis.-Ill.) 1953[2]	Midwest: Wis.-Minn. 1953[1]	Midwest: Michigan 1954[2]	Midwest: Iowa 1954[2]	Midwest: Minnesota 1955
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
30..........	---	---	---	---	---	---	---	---	---
60..........	---	---	---	---	---	---	---	---	---
50-80........	---	---	---	---	---	---	---	---	1,033
100..........	---	1,873	1,750-2,097	1,190-1,680	900-1,500	965	1,180-1,700	1,190-1,680	1,237
150..........	---	2,070	---	1,550-2,220	1,500-1,900	1,320	1,580-1,900	1,550-2,200	1,375
200..........	---	2,190	---	1,750-2,580	1,600-2,400	1,610	1,830-2,200	1,750-2,580	---
300..........	1,492	2,502	---	2,220-3,100	2,000-3,000	2,000	2,260-2,520	2,200-3,100	---
400..........	---	2,845	---	2,630-3,450	2,500-3,200	2,550	2,600-3,030	2,630-3,450	---
500..........	1,775	3,112	3,320-3,747	3,150-3,790	2,900-3,500	---	3,000-3,230	3,150-3,790	2,778
600..........	1,875	3,421	---	---	3,300-4,000	---	---	---	---
700..........	---	3,650	---	---	---	---	3,350-3,760	---	---
800..........	2,232	4,288	---	---	---	---	---	---	---
900..........	---	4,605	---	---	---	---	---	---	---
1,000........	2,350	4,853	4,700-5,574	---	---	---	---	---	---
1,500........	---	5,929	---	---	---	---	---	---	---
2,000........	---	7,019	6,178-7,820	---	---	---	---	---	---

Footnotes at end of table.

(Continued)

TABLE 36.--COST OF FARM BULK MILK COOLING TANKS, BY CAPACITY, REGION, AND YEAR--(Continued)

Tank capacity (gallons)	New England							Southeast	
	Rhode Island 1955	Vermont 1952[2]	Massa-chusetts 1952	New Hampshire 1953[1]	Connecticut			Maryland and Virginia 1952[1]	North Carolina 1955[2]
					1951[1]	1953[1]	1955		
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
30..........	---	---	1,000	---	---	---	---	---	---
60..........	1,000-1,200	---	1,200	1,033-1,200	---	---	---	---	---
50-80........	---	950-1,035	---	---	---	---	---	---	1,250-1,300
100..........	1,180-1,700	1,100-1,521	1,600	1,471-1,600	---	1,500-1,600	1,000	---	1,300-1,700
150..........	1,580-1,900	1,250-2,000	---	1,675-1,875	---	---	---	---	1,500-1,900
200..........	1,830-2,200	1,700-2,290	2,300	---	2,520	2,300	---	3,079	2,000-2,200
300..........	2,260-2,520	2,100-2,562	---	---	2,892	---	---	3,298	2,500-2,600
400..........	2,600-3,030	2,485-2,920	3,000	---	3,072	---	---	3,568	2,800-2,900
500..........	3,000-3,230	2,900-3,320	---	---	---	---	---	3,548	3,450
600..........	---	---	---	---	---	---	---	5,696	---
700..........	---	---	---	---	---	---	---	---	---
800..........	---	---	---	---	---	---	---	---	---
900..........	---	---	---	---	---	---	---	---	---
1,000........	---	---	---	---	---	---	---	---	---
1,500........	---	---	---	---	---	---	---	---	---
2,000........	---	---	---	---	---	---	---	---	---

[1] Installed.
[2] Installation extra.

Source: Compiled from reports of Agricultural Experiment Stations.

TABLE 37.--ANALYSIS OF CONTAINER COST FOR HANDLING MILK IN CANS

Item	Unit cost	Total cost	Annual cost	
			Per can	Per cwt.
California				
	Dollars	*Dollars*	*Dollars*	*Cents*
Can, carlots, 10-year life.......	6.00	6.00	---	---
Retinning, twice................	2.50	5.00	---	---
Lid replacement, 5% per year.....	.75	.38	---	---
Total per can..............		11.38	---	---
Investment in cans per 10 gallons of peak season milk production (2:1 float).........		22.76	2.28	---
Interest at 5% on average value..			.63	---
Can cost per 10 gallons of peak season milk production:				
Annual[1].....................			2.91	3.38
Daily.......................			---	0.009
Washington				
Can, carlots, 10-year life.......	9.00	9.00	---	---
Retinning, twice................	4.25	8.50	---	---
Lid replacement, 5% per year.....	1.45	.73	---	---
Total per can..............		$18.23	1.82	---
Interest at 2%, average value....			.20	---
Taxes and insurance..............			.20	
Annual investment cost per can[1]..			2.22	2.58
Can cost per 10 gallons of peak season milk production (2:1 float):				
Annual......................			4.44	5.16
Daily.......................			---	.014
Wisconsin				
Can............................	9.00	9.00	---	---
Annual investment cost per can[1]..			2.40	2.80
Can cost per 10 gallons of peak season milk production (2:1 float):				
Annual......................			4.80	5.60
Daily.......................			---	.016
Minnesota				
Cans, 64-lb. capacity (2:1 float)	8.60	17.20	---	---
Lid replacement, 1 for each 2 cans..........................	---	1.45	---	---
Retinning, twice per can.........	3.75	15.00	---	---
Total......................		33.65	3.37	---
Can depreciation per 10 gallons of peak season milk production, annual[1].....................			2.26	1.4

[1] Cost figure used in reference source for comparisons of farm cost for can and tank methods.

Compiled from reports of Agricultural Experiment Stations.

TABLE 38.--EQUIPMENT COST PER DAY AND PER HUNDREDWEIGHT FOR BULK TANK MILK-COOLING EQUIPMENT ON FARMS, BY CAPACITY AND REGION

Capacity		Cost per day as reported for:						Cost per day, per cwt. as reported for:					
		Calif.[1] 1947	Wash.[2] 1952	Oreg.[3] 1952	Wis.[4] 1952	N. H.[5] 1954	Vt.[6] 1954	Calif. 1947	Wash. 1952	Oreg.[3] 1952	Wis. 1952	N. H. 1954	Vt. 1954
Gal.	*Cwt.*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*
60	5.2	---	---	---	---	83	---	---	---	---	---	16.0	---
70	6.0	---	---	---	26.0	---	---	---	---	---	4.3	---	---
100	8.6	---	47.5	42.0	35.0	97	50.2	---	5.5	4.9	---	11.3	5.8
150	12.9	---	52.4	44.6	43.0	106	59.8	---	4.1	3.5	3.3	8.2	4.6
200	17.2	---	56.0	---	56.0	---	73.0	---	3.3	---	3.3	---	4.2
300	25.8	52.1	63.8	58.5	---	---	85.1	2.3	2.5	2.3	---	---	3.3
400	34.4	---	72.5	---	---	---	---	---	2.1	---	---	---	---
500	43.0	62.0	79.9	---	---	---	111.4	1.4	1.9	---	---	---	2.6
600	51.6	65.5	88.2	---	---	---	---	1.3	1.7	---	---	---	---
700	60.2	---	94.0	87.6	---	---	121.6	---	1.6	1.4	---	---	2.0
800	68.8	80.7	109.3	---	---	---	---	1.2	1.6	---	---	---	---
900	77.4	---	116.2	---	---	---	---	---	1.5	---	---	---	---
1000	86.0	83.6	124.4	---	---	---	144.3	1.0	1.4	---	---	---	1.7

[1] Depreciation 10 years, interest on undepreciated investment 4%.
[2] Depreciation 20 years for tank and refrigeration unit, plus 3-1/2% average annual repair and overhaul expense for refrigeration unit, plus interest and insurance.
[3] Depreciation 20 years, interest 5%.
[4] Depreciation 15 years, interest 5%.
[5] Amortization, plus interest at 16% total, for 3 years, on 3/4 original price less installation.
[6] Fixed costs 12% per year, including interest 5%, depreciation 6-1/2% (15 years, no salvage value), repairs 1.5%, insurance 1.5%.

Compiled from reports of Agr. Expt. Stas.

APPENDIX TABLE 39.--EQUIPMENT COST PER DAY AND PER HUNDREDWEIGHT FOR CAN MILK-COOLING EQUIPMENT OF FARMS, BY CAPACITY AND REGION

Capacity		Cost per day as reported for						Cost per day, per cwt. as reported for					
		Mechanical coolers				Immersion coolers		Mechanical coolers				Immersion coolers	
		Wash.[1] 1952	Wis.[2] 1952	N. H.[3] 1954	Vt.[4] 1954	Oreg.[5] 1952	Wis.[6] 1952	Wash.[1] 1952	Wis.[2] 1952	N. H.[3] 1954	Vt.[4] 1954	Oreg.[5] 1952	Wis.[6] 1952
Gal.	*Cwt.*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*	*Cents*
23	2.0-2.2	---	15	---	---	12.3	5.0	---	7.5	---	---	5.6	2.5
30	2.6	12.0	---	---	---	---	---	4.6	---	---	---	---	---
40	3.4	12.6	---	---	---	---	---	3.7	---	---	---	---	---
47	3.9-4.0	---	22	---	---	17.8	9.2	---	5.5	---	---	4.6	2.3
60	5.2	14.6	---	60.0	16.6	---	---	2.8	---	11.5	3.2	---	---
70	6.0	---	27	---	---	---	12.0	---	4.5	---	---	---	---
80	6.9	17.1	---	69.4	19.1	---	---	2.5	---	10.1	2.8	---	2.0
93	7.7-8.0	---	40	---	---	28.8	16.0	---	5.0	---	---	---	---
116	10.0	---	49	---	---	---	20.0	---	4.9	---	---	3.8	2.0
120	10.3	19.1	---	---	27.5	---	---	1.9	---	---	2.7	---	2.0
150	12.9	---	---	101.1	---	---	---	---	---	7.8	---	---	---
160	13.8	22.2	---	---	38.1	---	---	1.6	---	---	2.8	---	---
240	20.6-21.9	25.4	---	---	55.0	70.0	---	1.2	---	---	2.7	---	---

[1] Depreciation, interest and insurance, taxes and repairs on can cooler and compressor only; like items for cans not included but amount to $5.16 per cwt., per year, or $.014 per cwt., per day.

[2] Depreciation 15 years; interest 5%; milk can cost included and amounts to $2.40 per can or $2.80 per cwt., per year or $.008 per cwt. per day.

[3] Amortization, plus interest at 11% total, for 2 years, on 3/4 original price.

[4] Fixed costs 12% per year, including interest 5%, depreciation 6-1/2% (15 years, no salvage value), repairs 1.5%, insurance 1.5%

[5] Depreciation 20 years, interest 5%; plus can rental at 25 cents per can per month.

[6] Depreciation 15 years, interest 5%.

Compiled from reports of Agr. Expt. Stas.

TABLE 40.--CHANGES IN DAILY MILK VOLUME AND NUMBER OF CAN AND BULK SHIPPERS, FOR 64 IDENTICAL PLANTS, BY REGION, 1953 AND 1955.

Item	Northeast	Midwest	South	West	United States
1953					
Number of producers					
Can shippers................	2,921	2,887	1,503	2,318	9,629
Bulk shippers................	315	384	266	818	1,783
All shippers................	3,236	3,271	1,769	3,136	11,412
Average daily volume (pounds)					
Can shippers................	517	418	824	550	543
Bulk shippers................	1,083	932	1,308	879	990
All shippers................	572	478	897	636	613
1955					
Number of producers					
Can shippers................	2,344	1,970	960	1,372	6,646
Bulk shippers................	744	1,202	793	1,665	4,404
All shippers................	3,088	3,172	1,753	3,037	11,050
Average daily volume					
Can shippers................	507	416	881	401	512
Bulk shippers................	890	787	1,199	756	867
All shippers................	599	556	1,025	595	653

Compiled from survey data obtained by U. S. Farmer Cooperative Service (80, table 2).

LITERATURE CITED

(1) Abraham, S., and Outwater, C. H.
1944. Effect of Farm Cooling Methods and Transportation on Temperature of Night's Milk. Jour. Milk Technol. 7: 78-84, Mar.-Apr.

(2) Adams, C. S., Oldenburg, W. J., and Marshall, I.
1953. The Farm Tank and Its Problems. Skagit Co-op Dairyman 31 (4): 8-11, 16, 17, Dec.

(3) Agnew, D. B.
1955. Selected References on Bulk Milk Handling (Farm to Plant). U. S. Agr. Mktg. Serv., AMS-22, 24 pp., Mar.

(4) ________
1956. Farm-to-Plant Bulk Milk Handling Costs. Proc. 7th SW Milk Mktg. Conf., Okla. A & M College, Stillwater, Okla., May 17-18, pp. 6-13.

(5) ________
1956. Bulk Milk Handling Costs. Agr. Mktg. 1 (2): 6-7, Sept.-Oct.

(6) Alexander, M. H., and Ormiston, E. E.
1951. Methods of Milking and Milk Handling as Factors Affecting the Quality and Economy of Milk Produced. Jour. Dairy Sci. 34: 503-504, June.

(7) AMERICAN MILK REVIEW
1952. New England Looks at Bulk Handling. 14 (4): 50, 52, 54, 56, 58, 60, 90-91, Apr.

(8) ________
1953. 3-A Sanitary Standards for Farm Holding Tanks. 25 (9): 50, 52, 54, 82, Sept.

(9) ________
1953. How Western Dairy Organization Handles Problem of Financing Farm Tanks. 25 (9): 42, Sept.

(10) ________
1953. New Code for Measuring Milk in Farm Tanks. 25 (9): 44, 46, 48, 72, 73, Sept.

(11) ________
1953. Now 6550 Farm Holding Tanks in the U. S. 15 (9): 18-20, 22, Sept.

(12) ________
1954. 14,000 Farm Tanks in Operation. 26 (9): 102, 158, Sept.

(13) ________
1956. Girton Weighing System Puts Farm Tanks on Scales. 18: 98, Jan.

(14) ________
1956. Opportunity for Small Producer. 38 (12): 36, 38, Dec.

(15) Ames, R.
1953. Bulk Handling, A New Tool for Dairymen. Agr. Leaders' Digest 34 (6): 8-9, June.

(16) Anderson, T. G., and Nicholas, J. E.
1943. Influence of Cooling Methods on Milk Bacteria. Pa. Agr. Expt. Sta. Bul. 454.

(17) Arbuckle, W. S.
1953. Charting the Course for Tomorrow. Jour. Milk and Food Technol. 16: 141-142, May-June.

(18) Armstrong, F. K.
1952. Farm Installation and Calibration of Farm Tanks. Amer. Milk Rev. 14 (4): 54, 56, Apr.

(19) Atherton, H. V.
1955. Observations on Raw Milk Quality Before and After Conversion to Bulk Tank Pick-up at the Farm. Jour. Dairy Sci. 38 (6): 591, June.

(20) ________
1955. What Bulk Tank Should I Buy? Vt. Farm and Home Sci. 1 (2): 11, Oct.

(21) ______________, and Bradfield, A.
1955. What to Consider When Buying a Bulk Tank. Hoard's Dairyman 100: 1127, 1143, Dec. 25.
(22) ______________, Bradfield, A., and Gotthelf, P. E.
1955. Can Bulk Conversion Improve Quality? Milk Plant Monthly 44 (9): 15-17, 20, Sept.
(23) Babcock, C. J.
1947. Operation and Management of Milk Plants. U. S. Dept. Agr. Cir. 260, Rev.
(24) Baker, T. A., McDaniel, W. E., and Bondurant, B. L.
1954. Milk Handling, Can or Bulk Tank. Del. Agr. Expt. Sta. Cir. 29, 8 pp.
(25) Bartlett, R. W.
1951. Farm Tank Holdings of Milk. Ill. Agr. Ext. Farm Econ., (198/199): 1265-1267, Nov.-Dec.
(26) ______________, and Gothard, F. T.
1952. Measuring the Efficiency of Milk Plant Operation. Ill. Agr. Expt. Sta. Bul. 560, 56 pp.
(27) Baum, E. L., and Pauls, D. E.
1953. Comparative Analysis of Costs of Farm Collection of Milk by Can and Tank in Western Washington, 1952. Wash. Agr. Expt. Sta. Tech. Bul. 10.
(28) ______________, Riley, R. D., and Weeks, E. E.
1954. Economies of Scale in Operation of Can and Tank Milk Receiving Rooms, with Special Reference to Western Washington. Wash. Agr. Expt. Sta. Tech. Bul. 12.
(29) Baumer, E.
1955. Bulk Milk Tanks on Ohio's Farms. Ohio Banker 48 (10): 12-15, Dec.
(30) Beal, G. M.
1954. Problems Associated with Bulk Handling of Fluid Milk. 47th Ann. Conv. Milk Ind. Foundation Proc., Atlantic City, N. J., Oct. 25-28, Milk Supplies Sect., pp. 50-52.
(31) ______________, and Twining, C. R.
1953. Bulk Handling of Milk in the Washington, D. C. Milkshed. Md. Agr. Expt. Sta. Misc. Pub. 176, 39 pp.
(32) Bergman, T., and Rahmn, E.
1949. Influence of Distance and Duration of Transportation on the Durability of Milk. Internat'l. Dairy Cong. Proc. 12 (1): 424-433.
(33) Bethel, W. D.
1953. Bulk Handling of Milk. Wash. State Col. Inst. Dairying Proc., (22): 121-122.
(34) Bigwood, F. M., and Walsh, W. I.
1954. Bulk Handling Aids Processor Too. Food Engin. 26 (10): 100, 155, Oct.
(35) Birdsall, H. E.
1955. 100% Bulk Milk Pick-up. So. Dairy Prod. Jour. 57 (4): 28, 116-121, Apr.
(36) Blakley, L. V., and Brewer, D.
1954. Milk Test Variations in the Tulsa Milkshed. Okla. Agr. Expt. Sta. Bul. B-438, 10 p., Nov.
(37) Bloodgood, D. E.
1948. Milk Waste Disposal. Sewage Works Jour. 20 (5): 695-708, May.
(38) Boicourt, D. F.
1955. What Bulk Milk Handling Means to You. Impl. & Tractor 70 (12): 28-29, 80, 82-83, June 4.
(39) Boughton, C. W.
1954. From Cow to Consumer - A Quality Product Through Bulk Milk Pickup. So. Dairy Prod. Jour. 55 (5): 88, 90, 94, 96-97, May.
(40) Bowring, J. R.
1949. Milk Marketing in Local New Hampshire Markets. New England Res. Council Proc., pp. 94-96.
(41) ______________
1954. Tank-Truck Assembly of Milk for New Hampshire. N. H. Agr. Expt. Sta. Bul. 410, 24 pp., Mar.
(42) Bradfield, A., and Gotthelf, P. E.
1955. Butterfat Tests of Milk From Farm Bulk Tanks. Jour. Dairy Sci. 38 (6): 591, June.

(43) ________________, and Sinclair, R. O.
1953. Will Bulk Tank (Pickup) Replace the Milk Can in Northern New England? New England Homestead 126 (21): 14-15, Nov. 14.

(44) Bressler, R. G., Jr.
1942. Country Dairy Plants in Northern New England. U. S. Dept. Agr. and New England Res. Council, 34 pp.

(45) ____________
1942. Economies of Scale in Operation of Country Milk Plants in New England. New England Res. Council, 92 pp.

(46) ________________, and Hammerberg, D. E.
1942. Efficiency of Milk Marketing in Connecticut: 3. Assembly. Conn. Agr. Expt. Sta. Bul. 239.

(47) Bryant, C. B. A.
1948. The Milk Hauler. Milk Plant Monthly 37 (7): 72-74, July.

(48) ____________
1951. Florida Producers are Using Tank Trucks. Amer. Milk Rev. 13 (2): 62-65, Feb.

(49) ____________
1951. Bulk Handling of Milk - California. Amer. Milk Rev. 13 (7): 14-16, July.

(50) ____________
1952. Farm Tank Holding of Milk with Tank Truck Pickup. Jour. Milk and Food Technol. 15: 294-299, Nov.-Dec.

(51) ____________
1953. Economics of Farm Tank and Bulk Collection Program. Amer. Milk Rev. 15 (5): 52, 54, 72, May.

(52) ____________
1953. Farm Tank Holding of Milk with Tank Truck Pickup. So. Dairy Prod. Jour. 54 (2): 53-54, 56, 60, 62, Aug.

(53) ____________
1953. Each One a Little Different. Amer. Milk Rev. 15 (9): 56, 58, 60, Sept.

(54) ____________
1953. Economics of Farm Tank and Bulk Collection Program. Jour. Milk and Food Technol. 16: 260-262, Nov.-Dec.

(55) ____________
1954. Progress in Bulk Farm Tanks and Tanker Pickup. Jour. Milk and Food Technol. 17: 325-326, Oct.

(56) Buchanan, P. L., Cowan, R., Henderson, A. S., and Waananen, M. V.
1956. Impact of Bulk Tank Hauling on Costs of Hauling Milk and on Location Adjustment Provisions in a Federal Order. Wash. State Col. Inst. Dairying Proc. 25: 63-71.

(57) Buck, J. T., and Koller, E. F.
1949. Increased Whole Milk Procurement at Minnesota Creameries. Creamery Jour. 60 (8): 8, 25, 29, Aug.

(58) Bumstead, A. D.
1953. Tank Truck Pickup of Our Future Milk Supply. Ohio State Univ. Dairy Technol. Conf. 20, pp. 26-30.

(59) Burgess, R.
1945. Bacterial Problem of Milk Transport. Milk Indus. 26 (2): 61-63, Aug.

(60) Burroughs, C. L., and Burroughs, A. D.
1956. Successful Bulk Conversion. Milk Plant Monthly 45 (2): 22-23, Feb.

(61) Burton, G. L.
1952. Transportation of Milk From Farm to Dairy in a Part of the Montreal Milkshed. MacDonald Col. Tech. Bul. 19, 25 pp., Apr.

(62) Bushnell, H. H.
1948. Good Bye Milk Cans. West. Dairy Jour. 5 (1): 17, 36-38, Nov.

(63) Byrne, R. J.
1952. Rochester Dairy "Rolls Its Own." News Farmer Co-op 19 (8): 8-9, Nov.

(64) Calbert, H. E.
1952. Bulk Handling of Milk on the Farm. Milk Dealer 41 (7): 106-112, Apr.

(65) ___________
1954. The Bulk Milk Handling and Pipeline Milking on the Farm. Jour. Dairy Sci. 37 (12): 1485-1488, Dec.

(66) ___________
1955. Can Night and Morning Milk be Mixed in Tanks? Hoard's Dairyman 100: 356-357, Apr. 10.

(67) ___________
1956. Reducing the Error in Tank Milk Measuring. Milk Plant Monthly 45 (3): 26-28, 38, Mar.

(68) Capstick, E.
1953. Avoidance of Deterioration in Milk Quality During Transport. Internat'l. Dairy Cong. Proc. 13 (2): 201-207.

(69) Carter, R. M., Brundage, K. P., and Bradfield, A.
1951. Labor and Equipment Use in Milk Receiving Plants. Vt. Agr. Expt. Sta. Bul. 563, 71 pp., Sept.

(70) Charity, L. F.
1955. Bulk Milk Cooling in New York State. Address, Conf. on Bulk Handling of Milk on Farms, Va. Poly. Inst., Blacksburg, Va., May 24-25.

(71) Chelquist, G., and others
1950. Experiences in Cooperative Marketing of Dairy Products: Transportation. 5th Ann. Midwest Milk Mktg. Conf. Proc., Columbus, Ohio, Mar. 21-23, pp. 12-19.

(72) Clarke, D. A., Jr.
1947. Comparative Analysis of Costs of Operating Milk Collection Routes by Can and by Tank in California. Calif. Agr. Expt. Sta. Mimeo. Report 91.

(73) ___________
1952. Cost Relationships for Milk Collection by Can and by Tank in California. 16th Ann. Meeting Internat. Assoc. Milk Control Agencies Proc., Bar Harbor, Maine, Sept. 10-12, pp. 134-139, 140-143.

(74) Clodius, R. L., Fienup, D. F., and Kristjanson, R. L.
1956. Procurement Policies and Practices of a Selected Group of Dairy Processing Firms. 1. Some Aspects of Market Structure, Competitive Behavior, and Market Results. Wis. Agr. Expt. Sta. Res. Bul. 193.

(75) Conner, M. C., Spencer, L., and Pierce, C. W.
Specifications and Costs for a Milk Pasteurizing and Bottling Plant. Va. Agr. Expt. Sta. Bul. 463. (n. d.)

(76) Cotton, W. P.
1950. Farm to Plant Milk Assembly Rates and Problems in North Carolina. N. C. State Col., AE Info. Series 28.

(77) Cowan, R.
1956. Bulk Hauling - Its Savings. Milk Plant Monthly 45 (5): 19, 42, May.

(78) Cowden, J. M.
1952. Farm-to-Plant Milk Hauling Practices of Dairy Cooperatives. U. S. Farm Credit Admin. Bul. 69, 63 pp., May.

(79) ___________
1956. Farm-to-Plant Bulk and Can Hauling Costs. U. S. Farmer Co-op Serv. Rpt. 18, Mar.

(80) ___________
1956. Bulk Milk Handling in 1955. U. S. Farmer Co-op Serv. Gen. Rpt. 22, Apr.

(81) Craig, E. S.
1955. How About Bulk Milk Handling? Idaho Farmer 73: 41, Jan. 20.

(82) Cramer, C. A.
1954. A Study of the Cooling Efficiency of Farm Bulk Milk Tanks. MS thesis, Univ. Wis.

(83) Crosby, J.
1948. Dairyman Likes Bulk Milk Storage. Calif. Farmer (Northern Ed.) 188: 584, June 5.

(84) Cunningham, G.
1952. Does it Mean Goodby to the Milk Can? Iowa Farm and Home Register, Apr. 6.

(85) Cyr, V. M.
1954. Flavor and Odor in Tank Systems. Skagit Co-op Dairyman 31 (8): 6-8, Apr.
(86) Dahlberg, A. C., and Adams, H. S.
1950. Sanitary Milk and Ice Cream Legislation in the United States. Nat'l. Res. Council Bul. 121, 59 pp., July.
(87) ______ Adams, H. S., and Held, M. E.
1953. Sanitary Milk Control and Its Relation to the Sanitary, Nutritive and Other Qualities of Milk. Nat'l. Res. Council Pub. 250, 174 pp., Wash., D. C.
(88) DAIRY INDUSTRY COMMITTEE
1950. Waste Prevention in the Dairy Industry, 15 pp., Wash., D. C.
(89) DAIRY RECORD
1955. Connecticut Producers to Haul Own Milk. 55 (42): 22, Mar. 16.
(90) ______
1955. Ohio Dairy Group Warned to Go Slow on Converting to Bulk Tanks. 56 (28): 26, Dec. 7.
(91) ______
1956. Offer Tank Plan. 56 (36): 8, Feb. 1.
(92) ______
1956. Use New Method to Set Bulk Hauling Rates. 57 (4): 14, June 27.
(93) ______
1956. Declares Farmer in Middle on Bulk Tank Switch. 57 (30): 21, Dec. 26.
(94) Dalglish, F. W.
1943. Problems in Consolidating Truck Transportation of Milk in Vermont. Vt. Univ. Agr. Col. Dept. Animal and Dairy Husb. Short Course for Vt. Dairy Plant Operators and Managers 22: 43-48.
(95) Dankers, W. H., and Olson, F. L.
1955. What Shall it Be, Bulk Tank or Cans? Minn. Agr. Ext. Serv., 6 pp., Apr. (Processed.)
(96) Davis, C. O., Jr.
1954. Tank Conversion Route by Route. Milk Plant Monthly 43 (5):17, 19, 20, May.
(97) ______
1955. Bulk Pick-up Financing Plan. Milk Plant Monthly 44 (5): 23-24, May.
(98) ______
1955. Bulk Pick-up Gains Momentum. Milk Plant Monthly 44 (5): 15-17, May.
(99) ______
1956. Progress at Harmony, Racine. Milk Plant Monthly 40 (12): 43, Dec.
(100) Decker, C. S.
1953. Shall We Own or Lease Them? Internatl. Assoc. Ice Cream Mfrs. Proc., Rpt. 49 (1): 92-93.
(101) Decker, R.
1954. Operating Studies on Bulk Tanks. Dairymen's Price Reporter 36 (8): 2-3, 5, 13, Aug.
(102) Dehaven, G.
1951. Some New Aspects of Milk Receiving Operations. Calif. Dairyman 31 (6): 20, 22, 25-26, Apr. 21.
(103) ______
1951. New Receiving Room Techniques Developed in California. Amer. Milk Rev. 13 (6): 34, 36, 38, 89, June.
(104) ______
1951. Milk Receiving Operations. So. Dairy Prod. Jour. 50: 28, 74, 76, 78, July.
(105) Dodge, W. A., and Bradfield, A.
1956. They Put the Lasso Over Off-flavors. Milk Plant Monthly 45 (4): 31-32, 34, Apr.
(106) Dow, G. F.
1943. Country Assembly of Milk in Maine for Shipment to Boston. Maine Agr. Expt. Sta. Misc. Pub. 570.
(107) Dunham, G.
1954. Plant Experience Proves Oklahoma A. & M. Bulk Study Efficient. Milk Plant Monthly 43 (11): 13-14, Nov.

(108) Dunkley, W. L.
1955. California Experience with Rancidity Related to Pipeline Milkers and Farm Tanks. 48th Conv. Milk Indus. Found. Proc., St. Louis, Mo., Oct. 26-28, (Lab. Section): 53-57.
(109) ______________, and Kelley, L. A.
1954. Pipeline Milkers, Farm Tanks, and Rancidity. Calif. Dairyman 34 (17): 7, 11, 29-30, Sept. 18.
(110) ___________ and Kelley, L. A.
1954. Rancidity Increasing? Milk Plant Monthly 43 (10): 24-26, 54, Oct.
(111) Ealey, H. R.
1956. Getting 8 Pints From a Gallon: The Problem of Milk Measurement. Dairy Engin. 73: 5, Jan.
(112) Edmondson, J. E.
1955. Training Truck Drivers for Bulk Tank Milk Inspection. 48th Conv. Milk Indus. Found. Proc., St. Louis, Mo., Oct. 26-28, (Milk Supplies Section): 36-40.
(113) ______________, and Gholson, J. H.
1955. Bulk Pickup and the Hauler. Milk Plant Monthly 44 (5): 26-27, May.
(114) Eldridge, E. F.
1950. Waste Prevention in the Dairy Industry. Milk Dealer 39 (5): 49, 50, 88-94, Feb.
(115) Ellison, H. F.
1949. Recent Developments in Bulk Handling of Milk in Farm Tanks and Trucks. (1) How Bulk Handling Fits Into Company Operations. 42nd Ann. Conv. Milk Indus. Found. Proc., Los Angeles, Calif., Oct. 24-26, (5): 11-16.
(116) Erb, R. E., Goodwin, M. H., McCaw, W. M., Morrison, R. A., and Shaw, A. O.
1953. Lactation Studies: V. Causes of Variation in Fat Percentage. Wash. Agr. Expt. Sta. Cir. 229.
(117) Esmond, C. W.
1944. Spilled Milk. Milk Plant Monthly 33 (6): 34, June.
(118) Farrar, P. C.
1954. Symposium: Experiences with Bulk Handling - Effect on Plant. 46th Ann. Conv. Milk Indus. Found. Proc., Boston, Mass., Oct. 26-28, 1953 (Milk Supplies Section): 27-31.
(119) Fearn, B.
1954. Bulk Cooling's Coming Fast. Elect. Farm Mag. 27: 12-16, Jan.
(120) Feder, E., and Williams, S. W.
1954. Dairy Marketing in the Northern Great Plains - Its Patterns and Prospects. S. Dak. Agr. Expt. Sta. Bul. 438.
(121) Finnell, R. C.
1953. Bulk Handling of Milk on the Farm. 8th Ann. Midwestern Milk Mktg. Conf. Proc., Ames, Iowa, Apr. 1-3, pp. 17-18.
(122) Fischer, B. M.
1956. Bulk Milk Collection. Soc. Dairy Technol. Jour. 9: 138-139.
(123) Fisher, A. C.
1952. Five Years of Experience with Bulk Handling. Amer. Milk Rev. 14 (7): 18, 21, 22, 26, 52-53, 60, July.
(124) ___________
1952. Symposium: Will Bulk Tank Pickup Eliminate the 40-Quart Can? 45th Ann. Conv. Milk Indus. Found. Proc., Chicago, Ill., Sept. 24-26, 5: 45-55.
(125) ___________
1953. Bulk Tank System of Handling Farm Milk. Milk Dealer 42 (4): 45, 46, 58-62, Jan.
(126) Fisher, M. R.
1955. Quality Milk by Bulk Milk Pick-up System. 48th Conv. Milk Indus. Found. Proc., St. Louis, Mo., Oct. 26-28, (Milk Supplies Section): 33-35.
(127) Forest, H. L.
1956. Role of Governments in Pricing Fluid Milk in the United States. U. S. Dept. Agr. Dairy Situation, DS-256, pp. 29-56.

(128) Frazer, J. R., Nielsen, V. H., and Nord, J. D.
1952. The Cost of Manufacturing Butter. Iowa Agr. Expt. Sta. Bul. 389.

(129) French, C. E.
1954. Bulk Handling of Milk. Purdue Agr. Ext. Econ. and Mktg. Inform. for Ind. Farmers (unnumbered), pp. 4-6, Apr. 23.

(130) ________
1955. Bulk Tanks and Saved Steps. Ind. State Dairy Assoc. Ann. Rpt. 65: 18-24.

(131) ________
1956. How Much to Invest in a Farm Tank. Milk Plant Monthly 45 (3): 34-36, Mar.

(132) ________, and Strain, J. R.
1955. Bulk Milk Handling Needs Planning. Purdue Econ. and Mktg. Inform. for Ind. Farmers, pp. 2-4, Apr. 18.

(133) ________, Wood, G. B., and Manhart, V. C.
1952. Labor Utilization in Milk Receiving Rooms of Indiana Milk Plants. Ind. (Purdue) Agr. Expt. Sta. Bul. 576.

(134) Fuchs, E. R.
1954. One Hundred Percent Bulk Pickup. Milk Dealer 43 (10): 50-52, 67-68, July.

(135) Gemmill, A. V.
1952. Milk Tank Trucks are Banishing the Can. Food Engin. 24 (9): 143, 145, 213, 214, Sept.

(136) Gifford, C. W.
1953. Bulk Milk Tanks - Dairymen Like 'Em. Farm Jour. 77 (6): 36-37, 127, June.

(137) Gignac, A. E.
1952. Economics of Operating a Milk Plant on a 5-day Operation. 45th Ann. Conv. Milk Indus. Found. Proc., Chicago, Ill., Sept. 24-26, vol. 2, pp. 30-33.

(138) Gilman, W.
1952. Tanks Replace Their Milk Cans. Successful Farming 50 (1): 56, Jan.

(139) ________
1953. Milch Cows Without Milk Cans. New England Homestead 126 (17): 20-21, Sept.

(140) Goslee, H. C.
1952. Bacteria and Butterfat in Bulk Milk. Amer. Milk Rev. 14 (4): 60, 90, Apr.

(141) ________
1952. Symposium: Will Bulk Tank Pickup Eliminate the 40-Quart Can? 45th Ann. Conv. Milk Indus. Found. Proc., Chicago, Ill., Sept. 24-26, vol. 5, pp. 56-57.

(142) Gould, I. A., and Harper, W. J.
1954. Practices that Encourage Rancidity. 47th Ann. Conv. Milk Indus. Found. Proc., Atlantic City, N. J., Oct. 24-27, pp. 66-72.

(143) Greene, F. M.
1954. Farm Milk Tank Testing. U. S. Nat. Bur. Standards Misc. Pub. 212: 46-50.

(144) Gresham, Mary
1942. Labor Aspects of Chicago Milk Industry. U. S. Bur. Labor Statis., Monthly Labor Rev. 54 (6): 1283-1309, June.

(145) Hall, C. W.
1952. Efficiency of Labor and Equipment in the Receiving Room. 45th Ann. Conv. Milk Indus. Found. Proc. 2, Chicago, Ill., Sept. 24-26, pp. 12-24.

(146) ________
1953. Up Receiving-Room Efficiency. Food Engin. 25: 66-68, 184, 186, 188, 190, Apr.

(147) ________
1953. Engineer's Analysis of Bulk Milk Handling I. Milk Plant Monthly 42 (12): 13-14, Dec.

(148) ____________
1953. Performance of Dairy Plant Receiving Rooms. Agr. Engin. 34: 832-834, Dec.

(149) ____________
1954. Engineer's Analysis of Bulk Milk Hauling II. Milk Plant Monthly 43 (1): 41-42, Jan.

(150) ____________
1955. Bulk Pickup Electrical Costs. Milk Plant Monthly 44 (5): 20-22, May.

(151) Hammerberg, D. O., and Sullivan, W. G.
1942. Efficiency of Milk Marketing in Connecticut. 2. The Transportation of Milk. Conn. Agr. Expt. Sta. Bul. 238: 29 pp., Feb.

(152) Hanson, D.
1952. Less Work, More Profits with Milk Tanks. Successful Farming 50 (8): 46-47, 76, 80-81, Aug.

(153) Hargrove, P.
1955. Proper Gaging of Bulk Milk Coolers Using Dipstick. Amer. Milk Rev. 17 (6): 92, June.

(154) Hedges, I. R.
1947. Milk Can in Retreat. News for Farmer Co-ops. 14 (3): 6-7, June.

(155) Henderson, A. S., and Cowan, R.
1956. Bulk Hauling - Its Cost Problems, Its Savings! Milk Plant Monthly 45 (5): 18-19, 41-42, May.

(156) Henry, W. F., Bressler, R. G., and Frick, G. E.
1948. Efficiency of Milk Marketing in Connecticut. 11. Economies of Scale in Specialized Pasteurizing and Bottling Plants. Conn. Agr. Expt. Sta. Bul. 259, June.

(157) Herrington, B. L.
1954. Lipase: A Review. Jour. Dairy Sci. 37 (7): 775-789, July.

(158) Herrmann, L. F.
1950. Costs of Importing Milk, Memphis, Tennessee, 1948. USDA, Mktg. and Transportation Situation, MTS 80: 6-15, Jan.

(159) ____________
1955. Regulations Affecting the Movement and Merchandising of Milk. USDA, Mktg. Res. Rpt. 98, June.

(160) ____________, and Blum, J.
1954. Seasonality in Milk Receipts and Sales for Selected Federal Order Markets, 1947-51. U. S. Dept. Agr. Dairy Situation, DS 246: 14-17, Dec.

(161) ____________, Quintus, P. E., and Welden, W. C.
1942. Cooperative Reorganization of Milk and Cream Hauling. U. S. Farm Credit Adm. Misc. Rpt. 53, 33 pp.

(162) ____________, and Whatley, T. J.
1950. Costs and Margins of Milk Distributors in Memphis, Tennessee in 1948. U. S. Dept. Agr. and Tenn. Agr. Expt. Sta., unnumbered rpt., 30 pp. (Mimeo.)

(163) Hill, C. B.
1954. Change Paid Off. Hoard's Dairyman 99 (1): 17, 32, 33, Jan. 10.

(164) Hinckley, W. P.
1952. Basic Refrigeration Facts Involved in Bulk Cooling. Amer. Milk Rev. 14 (4): 58, Apr.

(165) HOARD'S DAIRYMAN
1954. We Like Bulk Handling (Round Table). 99 (5): 224-225, 248-249, 252-253, Mar. 10.

(166) ____________
1956. Bulk Tank Measuring Accuracy Improving. 101: 436, Apr. 25.

(167) Hollins, T. H.
1956. Bulk Handling of Farm Milk. Soc. Dairy Technol. Jour. 9: 110-116, July.

(168) Hoover, S. R., and Porges, N.
1952. Treatment of Dairy Waste by Aeration. U. S. Dept. Agr., AIC-332, 7 pp. (Processed.)

(169) Hulbert, R. H.
1955. A Study of Factors Concerning the Handling of Milk by the Bulk System. MA thesis, Univ. Wis., 40 pp.
(170) Hutchinson, J., and Hoyle, J. B.
1956. An Investigation into the Temperature Rise of Milk Stored Overnight in Cans Under Hot Weather Conditions. Soc. Dairy Technol. Jour. 9: 60-62, Apr.
(171) Jacob, A. W., and Seferovich, G. H.
1956. Progress in Bulk Milk Handling. Impl. & Tractor 71 (4): 58-60, Feb. 25.
(172) Jensen, M. W.
1955. An Experiment in Farm Milk Tank Gaging and Testing. U. S. Nat. Bur. Standards Misc. Pub. 216, pp. 112-116.
(173) ____________
1955. Farm Milk Tank Testing. 11th Ann. Dairy Technol. Conf. Proc., Univ. Md., College Park, Md., Nov. 15-16, p. 6.
(174) ____________
1956. Farm Milk Tank Testing. Milk Prod. Jour. 47 (5): 17-18, 20, 28, May.
(175) Johnson, P. E., Olson, H. C., and Von Gunten, R. L.
1954. Comparison of Bulk and Can Systems for Handling Milk on Farms. Okla. Agr. Expt. Sta. Bul. 436, 15 pp.
(176) Johnson, S.
1955. Premiums, and Reductions in Hauling Charges, Milk from Farms with Bulk Coolers. Conn. Agr. Ext. Serv. Dairy Mktg. (Monthly) Dec.
(177) ______________, and Henry, W. F.
1951. Formulas for Adjusting Milk Transportation Rates. Conn. (Storrs) Agr. Expt. Sta. Bul. 274, Mar.
(178) Jones, E. B., and Quackenbush, G. G.
1955. Milk Producers Entering and Leaving the Detroit Market. Mich. Agr. Expt. Sta. Spec. Bul. 397.
(179) Jones, G. W.
1946. Effect of Transit Conditions on Milk. Dairyman 63: 280, 281, 283, Aug.
(180) Judd, J. T.
1955. Bulk Milk Hauler is a Key Man! Hoard's Dairyman 100: 1081, Dec. 10.
(181) Juers, L. E., and Koller, E. F.
1956. Cost of Drying Milk in Specialized Drying Plants. Minn. Agr. Expt. Sta. Bul. 435.
(182) Keilholz, F. J.
1954. Put Down That Milk Can! Bulk Handling is Headed Your Way. Country Gent. 124 (12): 36, 37, 58-60, Dec.
(183) King, N.
1954. Influence of Agitation During Transport on Milk Fat. Austral. Dairy Rev. 22: 12, 16, Jan.
(184) Knoop, F.
1953. Milk Thru a Hose: Cooling Tanks and Tank Trucks. Farm Quart. 8: 36-39, 140-141, Spring.
(185) Knutzen, W. R.
1954. Tank Calibration. Wash. State Col. Inst. Dairying Proc. (23): 84.
(186) Kountz, R. R.
1954. Big Problem: Dairy Wastes. Food Engin. 26 (10): 89, 90, Oct.
(187) ____________
1956. Simplified Dairy Waste Treatment. Milk Dealer 45 (1): 60, 61, 64, Jan.
(188) Koval, F.
1955. Farm Bulk Milk Handling in Ohio. Milk Prod. Jour. 46 (8): 14-15, 36-37, Aug.
(189) Kutish, L. J.
1952. Regulations on Weight of Motor Trucks. U. S. Dept. Agr. Mktg. Res. Rpt. 28; 49 pp., Nov.
(190) Lamson, M.
1955. 5-Day Operation of a Milk Bottling Plant. Vt. Univ. and State Agr. Col., Dept. Animal & Dairy Husb. Papers at Conf. Dairy Plant Operators and Milk Distributors (34): 15-17, Oct.

(191) Larue, W. C.
1955. Modern Trend in Milk Handling. Prog. Farmer (Tex.) 70 (11): 52-53, Nov.

(192) LeBeau, K. L.
1952. How the Dealer Benefits (Bulk Handling of Milk). Amer. Milk Rev. 14 (7): 58, Apr.

(193) Liska, B. J., and Calbert, H. E.
1954. A Study of the Influence of Agitation Time on the Babcock Test of Milk Samples from Farm Holding Tanks. Jour. Milk and Food Technol. 17 (1): 14-17, Jan.

(194) Loui, D.
1945. Dairy Co-op for Trucking Their Milk. Prairie Farmer 117 (1): 10, Jan.

(195) Lucas, P. S.
1955. Arguments About Tanks. (In: Answers to your Milk Plant Problems). Milk Plant Monthly 44 (5): 53, 55, 56, May.

(196) MacLeod, A.
1943. Economics in Assembly and Distribution of Milk in New England. New Eng. Res. Council and Bur. Agr. Econ.

(197) ______, Carpenter, W. E., and Hitchcock, J. A.
1942. Savings in Assembly of Milk in Northern Vermont. U. S. Dept. Agr. jointly with Vt. Agr. Expt. Sta. and New Eng. Res. Council, Nov.

(198) ______, Tennant, J. L., and Corr, W. J., Jr.
1942. Trucking Milk to Providence, Rhode Island. U. S. Dept. Agr., Bur. Agr. Econ. coop. with New Eng. Council on Mktg., and R. I. Agr. Expt. Sta., Mar. (Processed.)

(199) Maits, B.
1951. Here Come the Tanks. Country Gent. 121 (8): 28, 61, 63-64, Aug.

(200) Manning, T., Felberg, R., and Benning, L.
1955. Whole Milk or Cream for South Dakota Dairies. MS Rpt., S. Dak. State Col., Agr. Econ. Dept.

(201) March, R. P.
1954. Farm Bulk Milk Handling. Jour. Milk and Food Technol. 17 (7): 210-213, July.

(202) ______
1954. Some Studies of Milk as Affected by Farm Tanks. Address 31st Ann. Meet. N. Y. State Assoc. Milk Sanitarians, Albany, N. Y., Sept. 21.

(203) ______
1956. Can You Afford a Bulk Milk Tank? Mutual Fed. of Ind. coop., Syracuse, N. Y. Milky Way 2 (4): 4, Apr.

(204) Marth, E. H., Hunter, J. E., and Frazier, W. C.
1954. Bacteriological Studies of a Farm Bulk Milk Handling System. Jour. Milk and Food Technol. 17 (3): 86-90, Mar.

(205) Matzen, E. H.
1947. Survey of Country Milk Collection Routes in the Ft. Wayne Area of Indiana. Ind. Agr. Expt. Sta. Bul. 520.

(206) McArthur, A. A.
1953. Bulk Farm Tanks and Tank Pickup. So. Dairy Prod. Jour. 53 (2): 34-35, Feb.

(207) McDaniel, W. E., and Pond, G. A.
1953. Changes in the Dairy Farming Picture. Minn. Agr. Expt. Sta. Bul. 416.

(208) Meanwell, L. J.
1945. Milk Transport from the Quality Standpoint. Dairy Indus. 10: 497-520, July.

(209) Merlin, D.
1955. Team Cooperation in the Bulk Milk Story. Milk Dealer 44 (9): 62-63, 100-102, 104-108, June.

(210) Metzger, H. B.
1954. Labor Utilization in Small-Volume Milk Pasteurizing Plants. Maine Agr. Expt. Sta. Mimeo Rpt. 49, 33 pp.

(211) Milk Dealer
1950. How Arden Saves $30,000 Annual Plant Loss. 40 (1): 48-49, 70-72, Oct.

(212) ________
1955. Shorty Tanker. 44 (9): 140, 141, June.

(213) ________
1955. Bubbles That Do Work. 44 (11): 43, Aug.

(214) ________
1955. Importance of Original Leveling Noted in Bulk Tank Survey. 44 (11): 124, Aug.

(215) Milk Plant Monthly
1953. Bulk Handling Operations. 42 (4): 49, 50, 67, Apr.

(216) ________
1954. Bulk Pickup at the Small Plant. 43 (5): 14-16, 23, May.

(217) ________
1954. Problems in Bulk Pickup. 43 (6): 23, 24, 31, 35, June.

(218) ________
1955. Plant Expansion Without Enlargement. 44: 21-22, Sept.

(219) ________
1956. Farm Tanks Freed of Rancidity Blame. 45: 40a, Feb.

(220) Miller, A. H.
1953. Economic Aspects of Bulk Milk Handling. Univ. Wis. Dept. Agr. Econ., 16 pp., Sept. (Processed.)

(221) ________
1956. Bulk Handling of Wisconsin Milk Farm to Plant. Wis. Agr. Expt. Sta. Res. Bul. 192.

(222) Miller, R. E.
1949. Cutting Costs of Milk Collection. Natl. Butter and Cheese Jour. 40: 40, Aug.

(223) Mojonnier, H. G.
1950. Receiving Milk by Tanker Pickup System. Milk Dealer 39 (6): 46-47, 107-108, Mar.

(224) ________
1954. Bulk Handling of Milk. (In: Letters to the Editor), Jour. Dairy Sci. 37 (9): 1139-1140, Sept.

(225) Morris, W. H. M.
1954. Recent Trends and Developments in Farm Milk Bulk Tanks. Dairy Indus. 19: 480-484, June.

(226) Morton, G. E.
1953. Bulk Handling Trend Works out Excellently in Milk. Calif. Dairyman 33 (2): 13, 19-20, 22, Feb.

(227) Moseley, W. K.
1953. Using Lab Findings to Trouble-Shoot Farm Quality Problems. 46th Ann. Conv. Milk Indus. Found. Proc., Boston, Mass., Oct. 26-28, Milk Supplies Sect., pp. 11-19.

(228) ________
1954. Pros and Cons of Bulk Cooling. Ind. State Dairy Assoc. Ann. Rpt. 64: 20-23.

(229) Murphy, D. H.
1956. Around Chicago - Milk's Going Bulk. Milk Dealer 45 (11): 44-45, 57-58, Aug.

(230) Myrick, N.
1951. Bulk Handling of Milk - Connecticut. Amer. Milk Rev. 13 (7): 10, 12, 58-59, July.

(231) ________
1951. Bulk Handling in Iowa. Amer. Milk Rev. 13 (11): 16, 18, 20, 22, 85, Nov.

(232) ________
1953. Where Do We Stand After 5 Years of Bulk Handling? Amer. Milk Rev. 15 (9): 10-13, 16, Sept.

(233) Nelson, A. P.
1956. $100,000 Volume in Bulk Milk Coolers. Farm Impl. News 77 (14): 24-25, 40, July 25.

(234) Nelson, G. T.
1953. Economic Aspects of Farm Tank Handling of Milk in Oregon. Oreg. Agr. Expt. Sta. Cir. Inform. 520.

(235) ———
1955. Bulk Milk Handling Can Provide Real Savings for Small Dairies. East. Feed Merchant 6: 78, 80, Jan.

(236) Nicholas, J. E., Watrous, G. H., and Decker, R. W.
n. d. Performance of Bulk Tank Milk Coolers Under Laboratory Conditions. Penn. State Col. Agr. Eng. Dept., 24 pp. (Mimeo.) (n.d.)

(237) Nielsen, A. R.
1955. Flavor Defects in Milk From Farm Pipelines and Tanks. 48th Ann. Conv. Milk Indus. Found. Proc., St. Louis, Mo., Oct. 26-28, Lab. Sect., pp. 58-60.

(238) Olson, J. C., Thomas, E. L., and Neilsen, A. J.
1956. Rancid Flavor - A Problem in Raw Milk. Minn. Farm and Home Sci. 13 (2): 5-6, Feb.

(239) Olson, R. E.
1953. An Analysis of Operating Costs of Selected Milk Dealers. U. S. Bur. Agr. Econ., 21 pp. (Processed.)

(240) ———, and Herrmann, L. F.
1956. Recent Findings About Milk Distribution Costs. U. S. Agr. Mktg. Serv., 5 pp. (Processed.)

(241) Owens, O.
1953. Bulk Farm Tanks. 8th Ann. Midwest Milk Mktg. Conf. Proc., Apr. 1-3, pp. 12-16.

(242) ———
1953. Prospects and Problems of Bulk Milk Handling. News for Farmer Co-ops 20 (9): 11-12, Dec.

(243) ———
1955. We Like Skip-Day Pickup. Hoard's Dairyman 100: 762, Aug. 25.

(244) Parkin, I. E., and Lynch, M. R.
1953. Farm Bulk Milk Cooling Tanks. Pa. State Col. Ext. Spec. Cir. 12.

(245) Parsons, M. S.
1955. How Does Bulk Milk Handling Affect Costs on Dairy Farms? U. S. Dept. Agr. Farm Cost Situation, ARS 43-29: 36-39, May.

(246) Pascoe, J. V.
1954. Fat Content of Milk Drainings From Storage Tanks. Austral. Jour. Dairy Technol. 9: 152-153, Oct.

(247) Pehrsson, E.
1949. Quality of Milk in Relation to Supplier's Distance From the Dairy and Size of His Deliveries. Internatl. Dairy Cong. Proc. 12 (1): 269-277.

(248) Perry, E. J.
1952. Bulk Tanks Replacing 10-Gallon Milk Cans. N. J. Farm and Garden 23 (10): 23, 71, Oct.

(249) Perry, R. L.
1951. Tank Truck Collection of Milk From Farms. Agr. Engin. 32 (9): 478-480, Sept.

(250) Pfautz, J. S.
1950. Milk and Fat Losses in Processing Fluid Milk. Milk Dealer 39 (10): 45-47, 85-95, July.

(251) Phillips, C. D.
1945. Collection of Milk and Cream From Farms in Kentucky. Ky. Agr. Expt. Sta. Bul. 479.

(252) Preston, H. J.
1954. Butterfat Sampling in Bulk Handling and Comparative Milk Solids Losses. U. S. Dept. Agr., Farmer Co-op Serv. Gen. Rpt. 10.

(253) Pritchard, N. T.
1951. Milk Hauling Costs Can be Reduced. Hoard's Dairyman 96: 135, 149, Feb. 10.

(254) ______

1951. Volume Discounts in Milk Hauling. Hoard's Dairyman 96: 309, Apr. 10.

(255) ______, and Cope, H. W.

1951. Milk Assembly in the Ft. Wayne Milkshed. Ind. Agr. Expt. Sta. Bul. 559, 24 pp., Feb.

(256) Prouty, C. C.

1955. Observations on Presence of Facultative Psychrophilic Bacteria in Milk Produced Under Farm Tank System. Jour. Milk and Food Technol. 18: 250-253, Oct.

(257) ______, Poe, G. C., Suckling, S., and Hurd, J.

1956. Flavor Problems in Bulk Tank Handling of Milk. Wash. State Col. Inst. Dairying Proc. (25): 143-153.

(258) Purcell, J. C., and Penny, N. M.

1955. Cost of Processing and Distributing Milk in the South. Ga. Agr. Expt. Sta., Southern Co-op Series Bul. 45.

(259) PURE MILK

1954. Bulk Tanks. 28 (1): 8, Jan.

(260) Randolph, J. W., Kidder, R. W., and Beardsley, D. W.

1955. Portable Milk Unit for 'Glades Dairy Industry. Fla. Grower-Rancher 63 (8): 14, 36, Aug.

(261) Rapp, H.

1954. Studies on Bulk Handled Milk. Jour. Dairy Sci. 37 (9): 1136, Sept.

(262) ______, and Calbert, H. E.

1954. Influence of the Bulk Handling of Raw Milk on Its Rennet Coagulation Time. Jour. Dairy Sci. 37: 637, June.

(263) ______ and Calbert, H. E.

1954. Study of Milk Losses as Influenced by Rate of Emptying Milk Cans. Jour. Milk and Food Technol. 17 (10): 317-319, Oct.

(264) Rennebohm, R. B.

1956. Before Installing a Bulk Tank - Check These Suggestions. Hoard's Dairyman 101: 850, 868, Sept. 10.

(265) Roland, T. D.

1953. Vacuum Tank With Pipeline Milking. Milk Plant Monthly 42 (11): 14-16, Nov.

(266) Rowe, G. A.

1952. Economics of Cheese Manufacturing in Tillamook County, Oregon. Oreg. Agr. Expt. Sta. Bul. 529.

(267) Rupp, R. G.

1952. Tomorrow's Dairying Today. Farmer (St. Paul) (Gen. Ed.) 70 (7): 9, 30-31, Apr. 5.

(268) Sanders, K.

1953. What's the Outlook for the Bulk Tank Pickup System? Milk Dealer 42 (11): 38-39, 50, 52, 54, Aug.

(269) Sartain, G. E.

1949. Tank Trucks for Farm Pickup of Milk. Milk Dealer 38 (11): 64-69, Aug.

(270) ______

1953. Symposium: Experiences with Bulk Handling - Effect on Quality. 46th Ann. Conv. Milk Indus. Found. Proc., Boston, Mass., Oct. 26-28, Milk Supplies Sect., pp. 24-26.

(271) Schabel, R.

1955. Bulk Tank Financing. Banking 32 (10): 72, 103-104, Apr.

(272) Schulz, W. G.

1956. Rancidity Problem May Be Solved. Hoard's Dairyman 101: 349, Apr. 10.

(273) Schwarzkopf, V.

1951. Little Drops of Wasted Milk Make a Mighty River. 44th Ann. Conv. Milk Indus. Found. Proc., Detroit, Mich., Oct. 24-26, 5: 44-50.

(274) ______

1951. Reducing Milk Waste in Dairy Plants. Milk Dealer 41 (2): 51, 52, 88-90, Nov.

(275) ——————
1954. The Milk Can's Future - and Its Relation to Quality. Milk Prod. Jour. 45 (2): 28-30, 45, 46, Feb.

(276) ——————
1954. The Milk Can's Future. Amer. Milk Rev. 16 (3): 34, Mar.

(277) Scott, R. A.
1953. Labor Utilization in Small-Volume Milk Pasteurizing and Bottling Plants. N. Y. (Cornell) Agr. Expt. Sta. Bul. AE 850.

(278) Searing, L. D., Loughary, I. H., Krumbah, M., and Prouty, C. C.
1955. Flavor Problems in Connection With Bulk Tank Handling of Milk. Wash. State Col. Inst. Dairying Proc. (24): 119-127.

(279) Shanhouse, W. M.
1953. Measuring Device for Farm Bulk Tanks. Milk Prod. Jour. 44 (10): 36, 39, Oct.

(280) ——————
1954. Surface Gaging Farm Milk Tanks. U. S. Nat. Bur. Standards Misc. Pub. 212: 44-46.

(281) Shirley, T.
1955. Are Milk Cans on Their Way Out? Rural Kentuckian 8 (10): 8-13, Oct.

(282) Sinclair, R. O.
1955. Economic Effect of Bulk Milk Handling in Vermont. Vt. Agr. Expt. Sta. Bul. 581, 35 pp., June.

(283) Smith, A. C., Dowd, L. R., and Anderson, E. O.
1955. Studies on a Portable Vacuum Bulk Milk Cooling Tank: 1. Effect of Daily vs. Alternate Delivery of Milk. Unpub. MS, Univ. Conn., Dept. Animal Indus.

(284) ——————
1955. A Portable Vacuum Bulk Milk Cooling Tank. Amer. Milk Rev. 17 (8): 56, 58, 102, Aug.

(285) Smith, E. H.
1952. What Can the Farmer Gain? (Bulk Handling of Milk). Amer. Milk Rev. 14 (4): 58, 60, Apr.

(286) Sonley, L. T.
1940. Cost of Transporting Milk and Cream to Boston. Vt. Agr. Expt. Sta. Bul. 462, 56 pp.

(287) SOUTHERN DAIRY PRODUCTS JOURNAL
1954. First in Georgia - Colonial Dairies Goes 100% Bulk Milk Pickup. 56 (5): 38, 39, 60, Nov.

(288) Spencer, L.
1949. Economic Study of Operations of Six Milk Companies in N. Y.-N. J. Metropolitan Area, 1941-48. N. Y. Agr. Col. AE 686, p. 36, Jan.

(289) Spindler, H. J.
1953. Farm-Bulk Tank Cost Estimates. Univ. Mass., Feb. (Mimeo.)

(290) Stall, C. W.
1953. New Milk Pickup System - From Cow to Bottle, Untouched by Hands. Hoosier Farmer 38 (6): 10-11, June.

(291) Steiger, P. E.
1955. Bulk Milk Cooler Study. N. Y. Farm Electrif. Council Prog. Rpt., pp. 38-41.

(292) Stocker, Noel
1952. Milk Tanks Now Here and Still Coming. News for Farmer Co-ops 19 (9): 8-10, Dec.

(293) ——————
1953. The Trend in Action - Maryland and Virginia Adopt Bulk Pickup. Calif. Dairyman 33 (2): 14-15, 18, 21, Feb. 21.

(294) ——————
1954. Progress in Farm-to-Plant Bulk Milk Handling. U. S. Farmer Co-op Serv. Cir. 8, 53 pp., Nov.

(295) Storck, R. E.
1951. Agitation of Milk by Air. Milk Dealer 41 (1): 52, 127, 130, Oct.

(296) Strain, J. R.
1955. Adapting Indiana Dairy Marketing Structures to Farm Bulk Handling of Milk. MS thesis, Purdue Univ., Jan.

(297) Strobel, D. R., Bryan, W. G., and Babcock, C. J.
1953. Flavors of Milk: A Review. U. S. Dept. Agr., 91 pp. (Processed.)

(298) Suckling, S. H.
1954. Farm Tank Pickup Problems - Tank Trucks. Wash. State Col. Inst. Dairying Proc. (23): 84-86.

(299) Swaner, J. J.
1952. Problems and Possibilities of Tank Transportation of Milk From the Farm to the Milk Plant. Papers presented at Midwestern Milk Mktg. Conf., Columbia, Mo., Apr. 2-3, p. 5.

(300) ______
1952. Symposium: Will Bulk Tank Pickup Eliminate the 40-Quart Can? 45th Ann. Conv. Milk Indus. Found. Proc., Chicago, Ill., Sept. 24-26, 5: 60-62.

(301) ______
1954. Economics of Farm Tank Pickup. 47th Ann. Conv. Milk Indus. Found. Proc., Atlantic City, N. J., Oct. 24-27, Accounting Sect., pp. 39-40.

(302) Swantz, A.
1955. Prices and Other Payments for Milk by Manufacturers in Kansas, Missouri and Oklahoma Markets. U. S. Dept. Agr. Mktg. Res. Rpt. 81, 40 pp., Mar.

(303) Swegle, W. E.
1955. You May Have to Buy a Bulk Milk Tank. Successful Farming 53 (12): 34-35, 64-65, Dec.

(304) Thom, E.
1949. Going Grade A. Milk Dealer 38 (12): 45-46, 108-116, Sept.

(305) ______
1952. Tank Truck Pickup of Farm Tank Bulk Milk. Butter, Cheese and Milk Prod. Jour. 43 (2): 26-28, 44, 46-48, Feb.

(306) ______
1952. National Trend in the Bulk Tank System of Handling Farm Milk. Milk Dealer 42 (1): 42, 63-66, Oct.

(307) Thomas, E. L., Nielsen, A. J., and Olson, J. C., Jr.
1955. Observations on Extent of Lipolysis in Raw Milk Supplies as Related to Various Milk Handling Practices. Paper M 38, Ann. Meet. Amer. Dairy Sci. Assoc., E. Lansing, Mich., June 20-23, Jour. Dairy Sci. 38 (6): 596, June.

(308) Thomsen, L. C.
1948. Plant Operation and Efficiency. Milk Dealer 37 (8): 47, 48, 140-148, May.

(309) Troy, W.
1955. Four Small Plants Become One to Challenge the Top Operators. Food Engin. 27 (2): 63, Feb.

(310) Turner, C. N.
1955. Bulk Milk Cooler Field Studies in Six States. Address, Amer. Soc. Agr. Engin. Ann. Meet., Chicago, Ill., Dec. 12.

(311) ______
1955. Excerpts From Bulk Milk Cooler Studies in Six States. N. Y. Farm Electrif. Council Prog. Rpt., pp. 17-37.

(312) ______, and Charity, L. F.
1954. Engineering Design and Operation of Bulk Milk Coolers on Farms. 31st Ann. Conf. N. Y. State Assoc. Milk Sanitarians, Cornell Univ., Ithaca.

(313) ______, Steiger, P. E., March, R. P., and Charity, L. F.
1954. Equipment for Bulk Cooling of Milk. Agr. Engin. 35: 247-251, Apr.

(314) UNITED STATES BUREAU OF LABOR STATISTICS
1942. Labor Aspects of Chicago Milk Industry. Bur. Labor Stat. Bul. 715, 53 pp.

(315) UNITED STATES NATIONAL BUREAU OF STANDARDS
1956. Testing of Farm Milk Tanks. Supplement to NBS Handbook 45, "Testing of Measuring Equipment," 29 pp.

(316) UNITED STATES PUBLIC HEALTH SERVICE
1951. Water Pollution in the United States. U. S. Public Health Serv. Pub. (64), 43 pp.

(317) ____________
1953. Milk Ordinance and Code: 1953 Recommendations of the Public Health Service. U. S. Public Health Service. Pub. (229).

(318) ____________
1953. Industrial Waste Guide to the Milk Processing Industry. U. S. Public Health Serv. Pub. (298), 14 pp.

(319) Van Lanken, G.
1956. Bulk Tank Cost per Hundred Pounds of Milk. Univ. Ill. Agr. Econ., "Farm Management Opinions," (114), June 11.

(320) Walker, S. H., Preston, H. J., and Nelson, G. T.
1953. Economic Analysis of Butter-Nonfat Dry Milk Plants. Idaho Agr. Expt. Sta. Res. Bul. 20, 90 pp., June.

(321) WALL STREET JOURNAL
1956. Dirty Water - Pollution Gets Worse. 147 (4): 1, 13, Jan. 6.

(322) Watrous, G. H., Jr., Nicholas, J. E., and Decker, R. W.
1955. Bulk Pickup Under Laboratory Conditions. Milk Plant Monthly 44 (5): 45-48, 50-61, May.

(323) ____________, Nicholas, J. E., and Decker, R. W.
1954. Performance of Bulk Tank Coolers Under Laboratory Conditions. 47th Ann. Conv. Milk Indus. Found. Proc., Atlantic City, N. J., Oct. 25-28, Milk Supplies Sect., pp. 32-45.

(324) Watt, J. E.
1955. Some Practical Aspects of Milk Bulk Haulage. Ontario Milk Prod. 31 (4): 9-10, Oct.

(325) ____________
1956. Some Practical Aspects of Bulk Haulage. Canadian Jour. Pub. Health 47: 347-351, Aug.

(326) Weber, C. W.
1953. Production and Transportation Experience and Problems (Milk). Jour. Milk and Food Technol. (16): 141, May-June.

(327) Webster, F. C.
1956. Specifications and Costs for a Moderately Small Milk Pasteurizing and Bottling Plant. Cornell Univ. AE 1031, 39 pp., May.

(328) Wells, W.
1952. The Farmer's Outlook (Bulk Handling of Milk). Amer. Milk Rev. 14 (4): 56, 58, Apr.

(329) Westbrook, F. A.
1953. Bulk Milk Routes are Increasing. Milk Indus. 33 (9): 66-70, Mar.

(330) WESTERN DAIRY JOURNAL
1952. Bulk Handling of Milk. 8 (8): 9, 11, June.

(331) ____________
1953. Economic Aspects of Farm Tank Handling of Milk. 9 (9): 19-20, July 1.

(332) Whiting, W. O.
1954. Problems Associated with Bulk Handling. 47th Ann. Conv. Milk Indus. Found. Proc., Atlantic City, N. J., Oct. 25-28, Milk Supplies Sect., pp. 56-57.

(333) Wildin, H. W.
1954. Tank Calibration. Wash. State Col. Inst. Dairy Proc. (23): 88-93.

(334) Williams, W. F., and Pritchard, N. T.
1953. Expectations and Plans of Milk Producers in the Evansville Milkshed. Purdue Agr. Expt. Sta. Bul. 594.

(335) Witzel, S. A.
1953. Pipeline Milker and Bulk Handling of Milk. Agr. Engin. 34: 157-158, Mar.

(336) ____________, and Cramer, C. O.
1955. Performance Characteristics of Various Bulk Milk Tanks. Jour. Milk and Food Technol. 18: 306-313, Dec.

(337) Woodruff, A. C.
1951. Tanker Pickup of Milk From Medium-Size Farms. Milk Dealer 40 (8): 48-49, 105, 106, May.

(338) ____________
1951. Green Valley Farms Adopts Bulk System for Collecting Milk on Farms. Milk Plant Monthly 40 (6): 72-75, June.

(339) ____________
1951. Bulk Handling of Milk - New Jersey. Amer. Milk Rev. 13 (7): 6-8, 61, July.

(340) ____________
1952. Bulk Handling (Milk) Is For the Family Farm, Too. Hoard's Dairyman 97: 278, 294-295, Mar. 25.

(341) ____________
1953. Bulk Milk Handling At the Farm and Plant. So. Dairy Prod. Jour. 53 (6): 49-52, 59-60, 62, June.

(342) ____________
1954. Some Observations on Bulk Milk Systems in the East. Amer. Milk Rev. 16: 65-66, 68, Jan.

(343) Wright, E.
1949. Interstate Shipment of Fluid Milk Supplies. Assoc. Food and Drug Off. U. S., Quarterly Bul. (13): 19-23, Jan.

(344) Zimmerman, C.
1951. Sundown for the Milk Can. Capper's Farmer 62 (13): 24, 59, Dec.

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